THE AUGUST SCIENTIFIC MONTHLY

EDITED BY J. McKEEN CATTELL

THE SCIENCE PRESS

LANCASTER, PA.—GRAND CENTRAL TERMINAL, N. Y. CITY—GARRISON, N. Y.

Yearly Subscription $5.00 Single Copies 50 cents

RECENT BOOKS OF SCIENTIFIC INTEREST

with comments by the publisher

Gould's Medical Dictionary. Edited by R. J. E. Scott. 1,398 pp. $9.00. P. Blakiston's Son & Company, Philadelphia.

Comprehensive. An extremely useful addition to any medical library. 76,000 words defined. Pronunciations also given. Based on recent medical literature with many tables.

The Human Body. *The Simple Guide Series.* Trevor Heaton. 242 pp. $3.00. E. P. Dutton & Company, New York.

A non-technical explanation of the human body, and the form and functions of its organs.

Hygiene and Sanitation. Jesse Feiring Williams. 344 pp. $2.00. W. B. Saunders Company, Philadelphia.

Dr. Williams presents the essentials of hygiene and sanitation; discusses individual and group efforts to attain and retain good health; points out definitely the close relationship between hygiene and sanitation and all health work.

Applied Psychology: Its Principles and Methods. A. T. Poffenberger. 574 pp. $4.00. D. Appleton & Company, New York.

A compact and authoritative survey of psychology in its practical applications, this work covers in an organized and systematic way the bearings of psychology on various occupations and professions as well as on individual efficiency in general.

The Autobiography of Benjamin Franklin. Edited by O. S. Coad. Cloth $ .80. Half leather $1.25. Macmillan Company, New York.

A popular priced and unabridged edition of the famous autobiography. Scientists will be especially interested in the account of the founding of Franklin's philosophical society, the Junto.

The Borderland of Music and Psychology. Frank Howes. 239 pp. $2.25. Oxford University Press, New York.

Some of the topics dealt with by Mr. Howes, one of the best known of the younger school of musical critics, are the behavior of audiences, the ethics of applause, and the value of rhythm in athletic training.

Statics and the Dynamics of a Particle. William D. MacMillan. 426 pp. $5.00. McGraw-Hill Book Company, New York.

A text-book in mechanics designed especially for students who are interested in astronomy, physics and mathematics and for those engineers who wish to extend their knowledge into the deeper foundations and developments of general theory.

Fundamentals of Astronomy. S. A. Mitchell and C. G. Abbot. 350 pp. $3.00. D. Van Nostrand Company.

This elementary text-book by two distinguished research astronomers subordinates the technical to the descriptive, and with great clarity of expression has developed the interesting aspects of astronomy to make the subject alive and charming.

Introduction to the History of Science. Volume I. Homer to Omar Khayyam. George Sarton. 839 pp. $10.00. Williams & Wilkins Company, Baltimore.

A comprehensive treatment which explains the development of one essential phase of human civilization, that of systematized positive knowledge. The arrangement of the book permits ready reference to any given period for the state of knowledge in that period. Extensive references for further study.

Graphical Mathematics. Theodore R. Running. 89 pp. $1.75. John Wiley & Sons, New York.

The following subjects are treated: Tracing the Conics, Graphical Computations, Decreasing and Increasing Geometric Series, Solution of the Quadratic and Biquadratic, Graphical Integration and Differentiation and Graphical Solution of Differential Equations of the First and Second Order.

Kernels of the Universe. C. B. Bazzoni. 18[illegible] pp. $1.25. George H. Doran Company, New York.

The author has avoided the pedantic manner of the usual sort in books containing scientific discussions. The atom—in all its significance—is discussed in a unique manner.

Statistical Mechanics with Application to Physics and Chemistry. Richard C. Tolman. 33[illegible] pp. $7.00. The Chemical Catalog Company, New York.

One of the American Chemical Society Monograph Series. Discusses the Classical Statistical Mechanics, the Quantum Theory, the Application of Molecular Processes and the Rate of Physical-Chemical Change.

Your Money's Worth: A Study in the Waste of the Consumer's Dollar. Stuart Chase and F. J. Schlink. 275 pages. $2.00. The Macmillan Company, New York.

A popular account of the plight of the consumer between the allure of the advertiser and the high pressure methods of the salesman. Also a plea for a bureau to test goods and supply information.

Readings in Urban Sociology. Scott E. W. Bedford. 873 pp. $5.00. D. Appleton & Company, New York.

The sociology of the city is here covered in a collection of important readings on various aspects of urban life and problems. The selections are arranged to make a systematic treatise covering a wide field.

// THE SCIENTIFIC MONTHLY

AUGUST, 1927

THE HISTORY OF THE ALPHABET

By Professor INGO W. D. HACKH

COLLEGE OF PHYSICIANS AND SURGEONS OF SAN FRANCISCO, CALIF.

THERE is no story more romantic than the story of the alphabet! Interwoven in this tale is the upward struggle of mankind—the search of adventure in distant lands, the trading expeditions to alien shores, the quest of dominion over alien tribes and races, and, most significant of all, the gradual expansion of human thought.

Think of the power which lies hidden in those apparently insignificant symbols which we call the alphabet! It is the carved, chiseled, engraved, written or printed word which preserves and advances civilization.

It is asserted that the discovery of fire was the greatest forward step of man, as it gave him comfort, protection, light and a means to master nature; but greater than this was the birth of an art which recorded man's thought and progress.

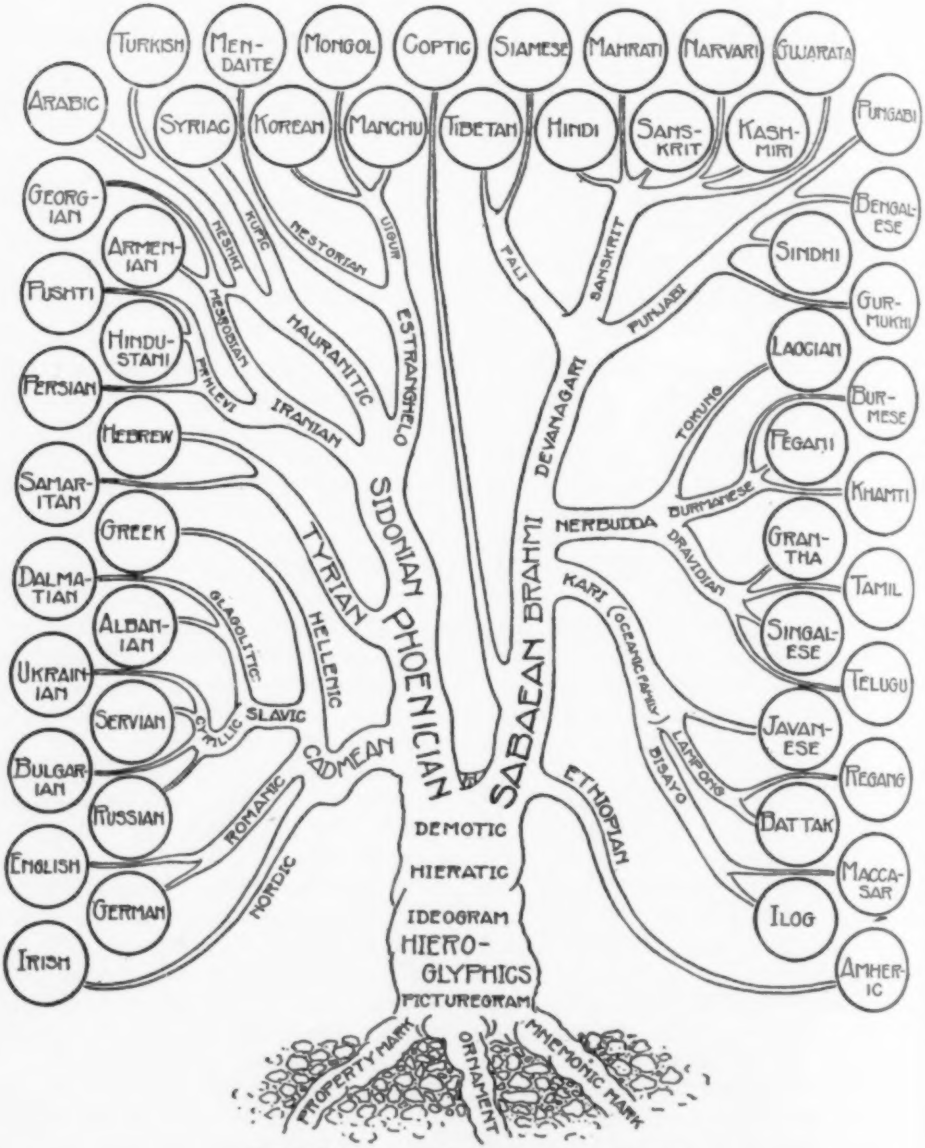
By this art man has achieved his cultural emancipation from a state of mere existence; this has enabled him to build the complex society of to-day, which depends upon the thoughts and works of our ancestors, for the "new things" of to-day required the "old things" of yesterday.

Whereas man at all times possessed the power of reasoning—that divine spark which separates him from the animal world and created the mental chasm never to be bridged—his progress has been slow. We find the development of the tool sluggish and hesitant: the masses always selecting the path of least resistance and timorously following in the footsteps of some more daring predecessor, driven only by dire necessity.

The idea of an alphabet did not come suddenly to the brain of some genius, but was slowly evolved during many generations and finally dawned hazily upon human consciousness. And to-day, after a few thousand years of practical use, man is still footstepping in precedents and has not found the courage to adopt an efficient alphabet. We still cling to archaic forms of spelling and burden our children with the complicated orthography by our refusal to progress—for:

The perfect alphabet should have a single character for each sound, and a single sound for each character.

Man copies, he has copied and keeps on copying! This human weakness illuminates the history of the alphabet. Whether Greek or Sanskrit, Russian or Siamese, German or Hebrew, we can trace all back to a common origin. From all four points our path leads to the cradle of civilization in and around Asia Minor. There we find during archaic times several forms of writing, hieroglyphics and cuneiform, developed from crude picture writing. In following the trail still further we find the ancestors of both and come then to the misty past where the tracks have been



THE FAMILY TREE OF ALPHABETS

THE COMMON SOURCE OF ALL ALPHABETS ARE THE HIEROGLYPHICS OF EGYPT. FROM THEIR SIMPLIFIED FORM, THE DEMOTIC, THE ANCIENT HEBREW TRIBES BORROWED THEIR SYMBOLS WHICH SPREAD THROUGH THE AGES TO ALL QUARTERS OF THE GLOBE, THUS LINKING THE ALPHABETS OF IRELAND, ABYSSINIA, INDIA AND MONGOLIA AND INTERMEDIATE POINTS INTO ONE GREAT FAMILY.

erased from man's consciousness and of which no records have survived.

Earliest Traces of Writing

Property marks

On nearly every prehistoric site the archeologist finds some symbols or characters, painted or chiseled on rocks or stone. Many of these markings are undecipherable—they are not pictures but characters which belong to no known alphabet. They are usually simple and may resemble some of our modern letters, such as I, T, A, Z or M. On pebbles in France, Switzerland and Germany, on fragments of pottery in Egypt, centuries before the dawn of civilization, and on rocks in the caves of Nevada, these markings have been made by the primitive savage.

Such symbols are assumed to indicate ownership, they were the property marks of the primitive savage and placed upon his utensils, tools and weapons—just as we are in the habit of putting initials on our fountain-pens and automobiles, ex-libris in books and monograms on tableware and jewelry.

If there were among the primitive potters one whose skill was greater and consequently his ceramic creations of better grade, such superiority was bound to become known; his pottery was a thing to be coveted, and in peaceful times his mark became a trade-mark because his goods were articles of exchange. So as time went by the property mark changed from denoting the possessor and became the trade-mark indicating the maker.

The Second Period of Writing

Mnemotechnic marks

As man became more sociable and began to trade with his neighbor, besides making war, there came a period when he needed some device for refreshing his memory regarding his transactions. Likewise, he may have wanted to send messages to distant friends. Here the trail becomes clearer, for we can observe the means employed by primitive races in historic times and assume that similar means have been used by the primitive savage of prehistoric time.

Among the primitive Australians we have a wooden stick with notches. The Peruvians had the quibu, strings of different colors with differently tied knots.

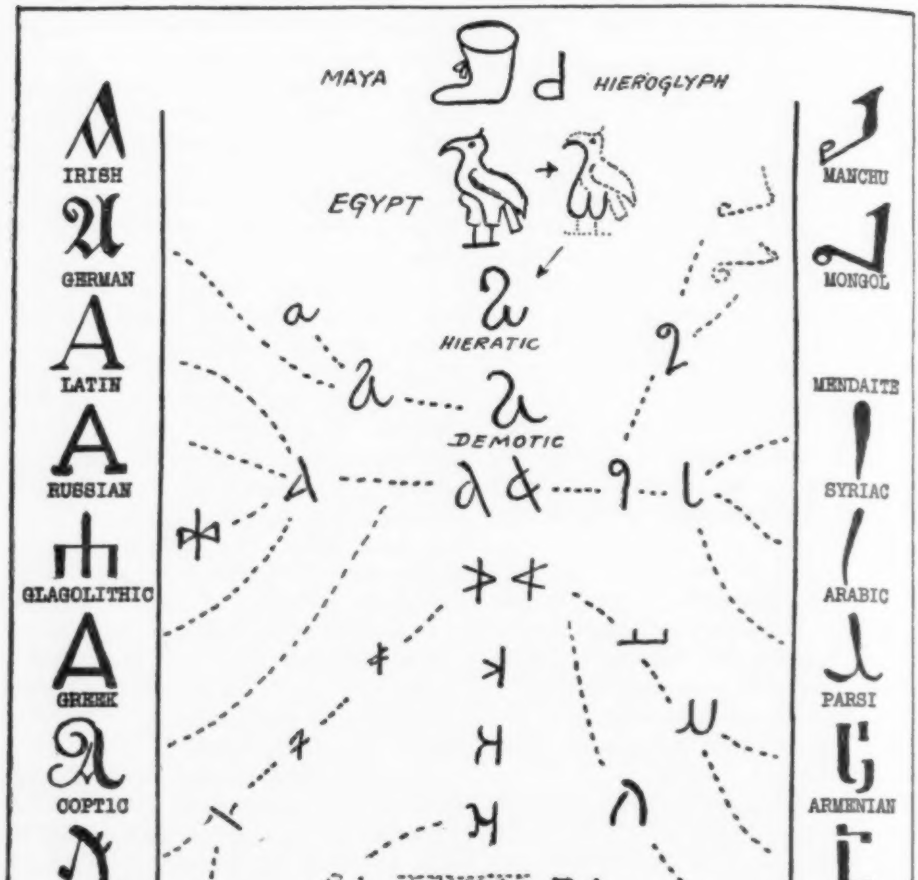
An illustration of a mnemotechnic device is also Robinson Crusoe's calendar—a short notch for weekday, a longer notch for Sunday. Or even a more realistic example is the custom of counting by strokes: |||| |||| |||. These marks may mean bunches of bananas or barrels of wine, cakes or cattles, and are thus void of meaning, except to those who made them. This is the distinguishing feature of all mnemotechnic devices, and there are many of them. The field is unlimited, even to-day we tie a string around our left thumb, knot our handkerchief, or put the watch in another pocket as a reminder of something which we usually forget.

Many of the mnemotechnic devices have become conventionalized, so that the receiver of a message stick or a quibu may guess at the meaning without the oral explanation of the messenger. Some of our present-day customs trace back to such conventionalized mnemotechnic devices. For example, the olive branch, offering salt, handing the key of the city, or even shaking hands as a sign of good will.

The Third Period in Writing

Picturegram

The mnemotechnic device was at its best undependable and indefinite and with increasing mental activity and social complexity man was forced to take the next step which led to the pictogram or picturegram. Man attempted to draw the likeness of the object. A hunt or battle, with so many slain and so many



A

THE THREE STROKES OF A CAN BE RECOGNIZED IN THE HEBREW CHARACTER AS WELL AS IN THE INVERTED K FROM WHICH THE INDIAN ALPHABETS ARE DERIVED. IT LOSES THE HOOK IN ARABIC AND SYRIAC, LIES ON ITS SIDE IN MONGOL AND MANCHU AS WELL AS IN ARMENIAN AND GEORGIAN AND BECOMES RATHER FANCIFUL IN SOME OF THE INDIAN CHARACTERS.

captured—crude pictures of animals or of men, with or without their heads—were sufficient to tell the tale.

Such pictures we can see in the museums on hides, ivory, pottery, wood and fabrics—the work of Indians, Eskimos, African and Australian tribes.

Records of the past indicate that the ancient tribes in Egypt, Assyria and China pursued the same method and that picturegrams were the oldest forms of writing.

Crude pictures are sufficient. And with frequent use the picture stories and picture messages become more conventionalized and simplified. Thus they developed into cuneiform characters in Assyria, into hieroglyphics in Egypt and into Chinese symbols in China.

The Fourth Important Step
Ideogram

Sooner or later the picture alone becomes insufficient to express the thoughts and ideas developing in man's consciousness. Man's thought grew from the concrete to the abstract—he conceived more complex and more highly developed ideas which reached outside the physical world. Thus pictures of objects became insufficient and the necessity came of taking another forward step in the art

A PICTURE MESSAGE

A MESSENGER CAN NOT BE SENT OR SPARED, AS ALL THE MEN HAVE GONE ON A LONG HUNTING TRIP AND WOMEN, CHILDREN AND DISABLED MEN ARE LEFT IN THE CAMP. THE FOOD GIVES OUT AND THE CAMP HAS TO BE MOVED BEFORE THE HUNTERS RETURN. SO THEY PACK UP AND GO AND AS THERE ARE NO TYPEWRITERS THE STENOGRAPHER WILL CUT A PIECE OF WOOD OR BONE WITH THE ABOVE MESSAGE, ASSURING AND DIRECTING THE HUNTERS: (1) AND (2) IN THE HUT (3) NOTHING (OUTSTRETCHED ARMS HAVE THE UNIVERSAL MEANING OF NOTHINGNESS) (4) TO EAT OR DRINK. (5) FOUR SUNS (OR DAYS) (6) IN THIS DIRECTION (7) BY BOAT OR CANOE.

A MESSAGE STICK

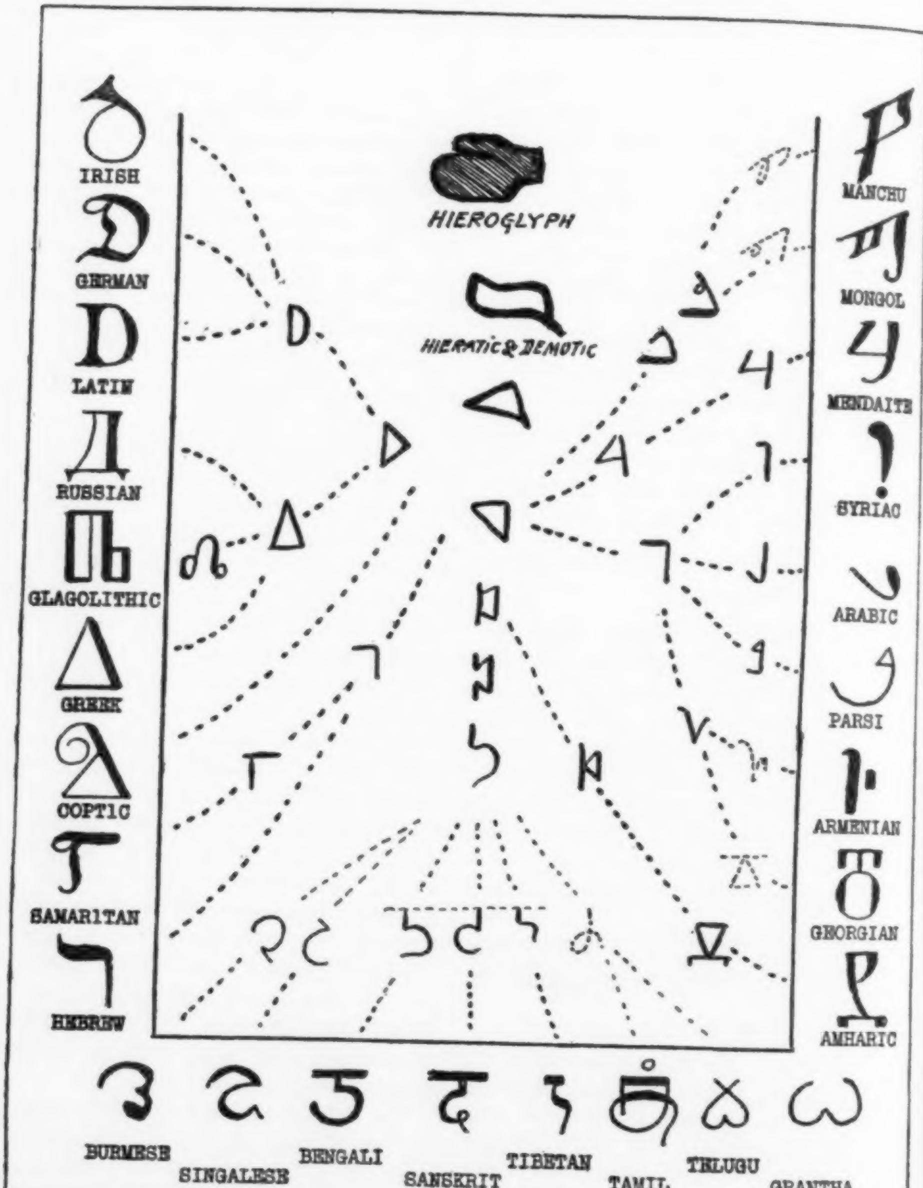
A WOODEN STICK WITH NOTCHES SERVES AS A MNEMOTECHNIC DEVICE AND WE MIGHT IMAGINE A NATIVE CHIEF INSTRUCTING HIS MESSENGER AS HE CUTS THESE NOTCHES: (1) THAT BIGGEST NOTCH—THAT'S ME—(2) THESE ARE MY TWO BROTHERS, AND (3) THESE ARE MY THREE BOYS. NOW YOU GO (4) FIVE DAYS' JOURNEY AND INVITE (5) MY NEIGHBOR CHIEF AND HIS THREE BROTHERS, THESE FOUR NOTCHES, TO THE INITIATION OF MY THREE BOYS WHICH WILL BE (6) IN FIFTEEN DAYS.

of writing—the development of the ideogram.

Just as we reason from particular incidents the general behavior, so our early ancestors were ingenious in combining pictures of particular objects, to express a general idea for which he could draw no picture. This process is well illustrated in the history of the Chinese characters, which at the present time are but conventionalized symbols of object-pictures.

For example, the idea "light" is too intangible to be pictured. Some ancient Chinese philosopher solved the problem arbitrarily by combining the pictures of the "sun" and "moon." Thus by combining the concrete he reached the abstract—however still vague and uncertain, for "sun-moon" may just as arbitrarily mean "time" or a "24-hour-day." Numerous and interesting are these combinations, "two woman" means jealousy, and "three woman" stands for gossip.

Not only in China, but also in Assyria, in Egypt and in Central America, in cuneiform, heiroglyphic and Maya symbols this development of combining characters took place. So the number of ideograms multiplied and grew into thousands. Writing became a complicated art, mastered only by few. In time the true meaning of many of these ideograms became obscure, and the characters had to be learned by memory.



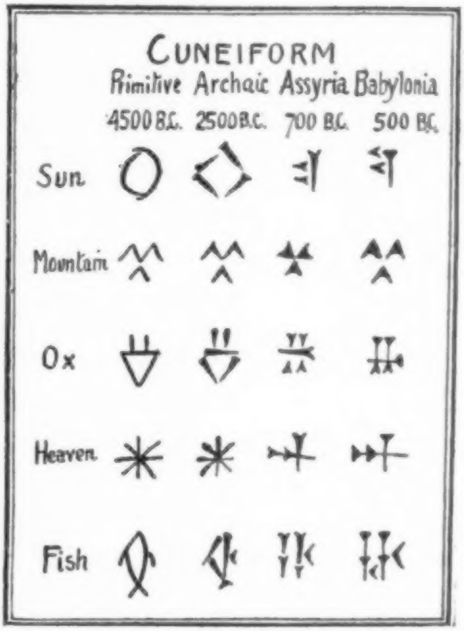
D

THE LETTER D DEVELOPED FROM A TRIANGLE, WHICH LOSES ITS HYPOTENUSE IN SAMARITAN AND HEBREW; BECOMES OPENED AND ROUNDED IN THE INDIAN ALPHABETS; ABRIDGED IN SYRIAC AND ARABIC; AND FANCIFUL IN MANCHU AND MONGOL.

Many are the shortcomings of the ideogram, and to make matters seemingly more easy, but in reality more complex, classifying symbols were added to the ideograms. These classifying symbols or determinatives were used to put the idea or object of the hieroglyphic into a certain group: all things concerned with man had a picture of a man attached to the ideogram, everything related to plants a flower or tree, to buildings, a house, to countries, a mountain; all ideas connected with motion, the symbol "go," usually a picture of two walking legs.

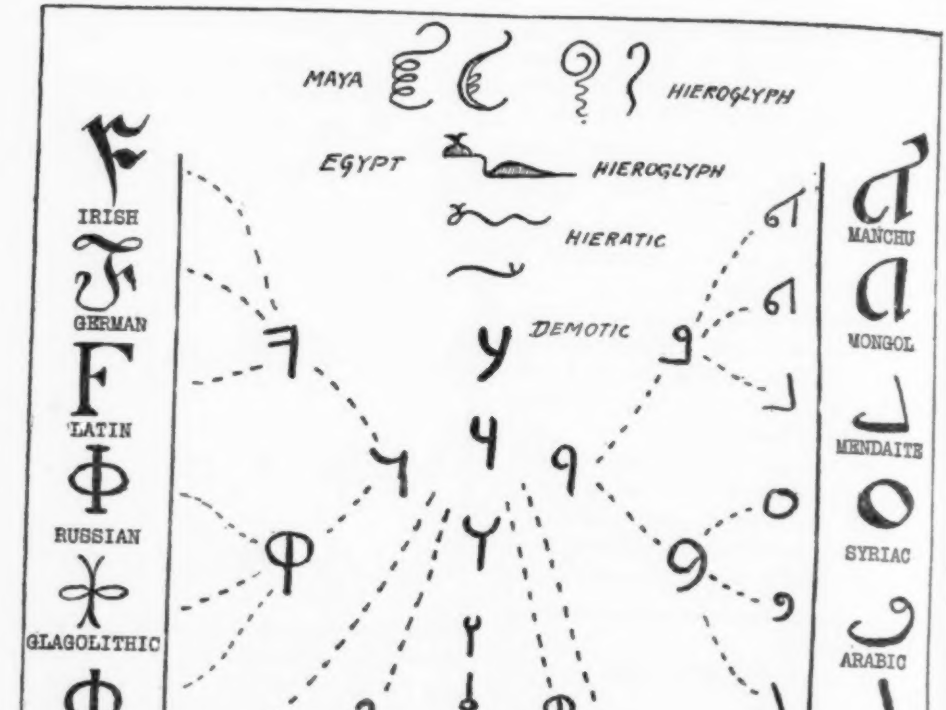
Writing was now an intricate art and began to exert its mighty power upon mankind. It became surrounded by mystery and sacredness in the minds of the masses, which was by no means intentional on the part of the few who could write and read. To the acute observative mind of the people the symbols became beings and spirits which made those who read them, usually the priests and scribes, "talk," and more wonderful yet, it made different priests at different times or different places "talk the same way." (Curiously enough, we still use the phrase, "What does it say?" and never inquire, "What does it read?" when we are puzzled by an undecipherable writing.)

THE SHORTCOMING OF THE PICTUREGRAM WAS REALIZED IN EGYPT, ASSYRIA AND CHINA, FOR AN ABSTRACT IDEA CAN NOT BE EXPRESSED BY CONCRETE OBJECTS. THUS IT BECAME NECESSARY TO PLACE BEFORE OR AFTER A CHARACTER A DETERMINATIVE, TO INDICATE THE GROUP OF THINGS WHICH THE SYMBOL SHOULD REPRESENT. THIS ADDED TO THE COMPLEXITY AND CONFUSION AND MADE WRITING STILL MORE DIFFICULT.



THE CUNEIFORM WRITING LIKEWISE DEVELOPED FROM PICTURE WRITING. IF THERE HAD NOT AT THE SAME PERIOD DEVELOPED AN ALPHABETIC WRITING FROM THE EGYPTIAN HIEROGLYPHICS, IT IS VERY PROBABLE THAT THE CUNEIFORM CHARACTERS WOULD HAVE BECOME THE BASIS OF AN ALPHABET.

Not all the primitive ideograms reached the perfection attained in Egypt, China and Central Asia. Indian picture-writings barely began to use determinatives and the Alaskan ideograms served mainly genealogical and religious purposes on totem poles.



F

THE LETTER F AND PH TRACES BACK TO THE EGYPTIAN HIEROGLYPH REPRESENTING A HISSING SNAKE AND CURIOUSLY THE MAYA HIEROGLYPH DEPICTS LIKEWISE A SNAKE. IN ITS DEVELOPMENT THE DEMOTIC FORK PASSES UNCHANGED TO THE COPTIC, GEORGIAN AND ARMENIAN SYMBOL, BECOMES DOUBLE-FORKED (DIGAMMA) IN THE LATIN, GERMAN AND IRISH F, AND CHANGES TO A LOOP IN MANY OF THE REMAINING ALPHABETS.

Only the Egyptian hieroglyphics developed further into an alphabet—the Chinese remained in the *status quo* and became conventionalized into the modern characters used in China to-day. Assyrian and Maya writing died out, the first because progress was made with alphabetic characters close by, the second on account of political changes which destroyed the Maya culture.

Yet ideograms are still with us in the form of many symbols used in art, heraldry, church, fraternal organizations and daily life. The propeller and wing does not mean a propeller and a feathered wing but is the insignia of "aviation." In the political zoo we have the moose and elephant, in the international arena the lion of England, rooster of France, bear of Russia and the dachshund of Germany; likewise in the botanical garden grows the thistle of Scotland and the shamrock of Ireland, the cherry blossom of Japan and the lotus of India.

The Fifth and Final Step

Phonograms

The time came when the soul of poets, prophets and philosophers awakened and upon man's vision dawned the spiritual world of justice and God, of morals and ethics. During this epoch the great epics and legends of heroes and demons, of Good and Evil were created and the virgin soul of man burst forth in song and passed it on from mouth to mouth until the impulse of recording these more abstract thoughts overcame the inadequate means of writing. This led to the birth of the phonogram.

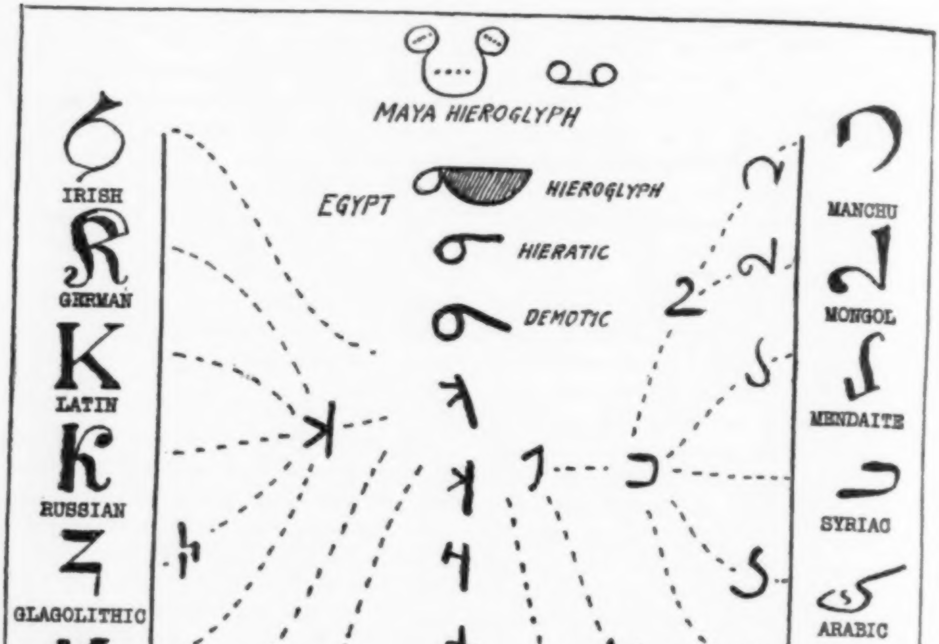
The phonogram was a conventional and arbitrary use of the picturegram. For instance, to convey the general concept of "charity" there would be an endless number of picturegrams depicting particular cases, but restricting the picturegram to the first syllable of the object depicted, we would phonetically spell the word by drawing a "CHAriot," a "RIver" or "RIbbon" and a "TIle" or "TIger." Thus the picturegram does no more indicate the object, but its first syllable. From the syllabary "cha-ri-ti" developed in time the consonant writing "ch-r-t" which still survives in Hebrew, Arabic and Turkish. But this consonant writing is likewise unsatisfactory, for "chrt" may just as well mean "chart," "chariot" or "cheroot." Hence in later times an auxiliary system of indicating vowels had to be adopted, from which sprang the consonant-vowel writing of the European races.

The Development of the Alphabet

The hieroglyphics of ancient Egypt are the parents of all our modern alphabets. Whether these hieroglyphics have been developed by primitive Egyptian tribes or whether they have come from a still more remote form of writing, originating in the mysterious Atlantis, is doubtful. The later hypothesis is based upon the striking similarities between Maya hieroglyphics and Egyptian hieroglyphics, which would point to a common origin in the sunken continent of Atlantis.

But the immediate cradle of our alphabets stood in Egypt where the priest was the guardian of the secret of writing for recording political history and moral thought. Among the oldest of records is the moral concepts of Ptah Hotep, which dates around 3600 B. C. About eight hundred years later came the famous "Book of the Dead," which describes graphically the wanderings of the soul after death and the final judgment day on which the soul is weighed against a feather in the presence of Good and Evil and followed either by destruction or eternal happiness.

By this time writing had developed from the pictures to the ideograms and phonograms, and now came in addition to the already complex hieroglyphics an abbreviated form which was used as a cursive writing on papyrus, skin or wood. This was the hieratic or sacred



K

The letter K and its cousin Qu are both derived from the loop-like demotic character, which becomes angular when carved in stone. Irish and Coptic preserve the Qu-shape, while the Indian alphabets passed through a cross-shaped character; the Samaritan, and Armenian, metamorphosed from a figure resembling "4," which is reversed in Georgian, and turned upside-down in Amharic.

writing—the hieroglyphics or "sacred carvings" became restricted for use on stone and rock. We have now two styles of writing, the beautifully carved hieroglyphics and their abridged form, hieratic, which became more and more condensed and finally a mere outline of the original hieroglyphics.

As society progressed the "sacred" nature of writing became better understood by the masses, and the tradesman and soldier used a still more simplified form, the demotic (from the Greek *demotikos,* belonging to the people) derived from the hieratic (Greek *hieraticus,* belonging to the priest). Writing had now become a common art, and the first library was founded in Thebes around 1700 B. C. Here manuscripts were transcribed and the records and scrolls of deeds and acts kept.

A hundred years later, 1600 B. C., a summary of the medical knowledge, a medical encyclopedia, was collected in what is known as the Papyrus Ebers, named after its discoverer.

About the same time Moses led the Israelites to Canaan after he had learned the art of writing in Egypt. Whether the Hebrews in general became acquainted with writing in Egypt or whether the Egyptian emissaries and traders carried the demotic into Palestine, certain it is that the Semitic tribes, during this period, adopted and adapted the demotic writing to their own language.

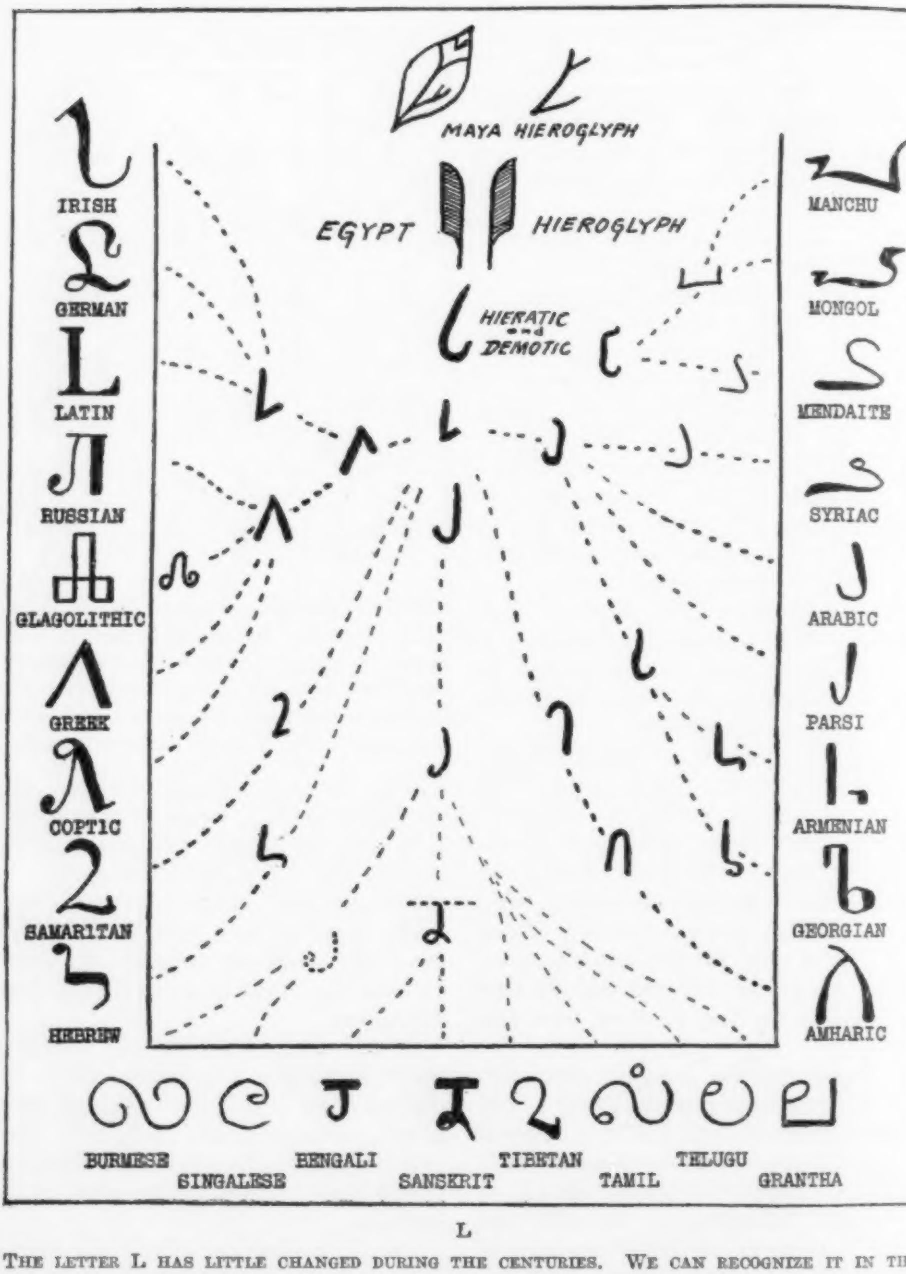
In borrowing the demotic characters the Hebrews took unconsciously a stupendous forward step, for they selected but twenty-two characters from the multitude of Egyptian symbols. In Egypt the many hieroglyphic, hieratic and demotic characters prevented the general diffusion of the art of writing, which was made still more complex by a possible threefold use of one and the same hieroglyphic, as it could be used as ideogram (representing the object which it pictured), as a phonogram (representing the first syllable or vowel of the object), or as a determinative (representing the class to which the object belonged).

PHOENICIAN AND ASOKA GREW ON THE SAME STEM. FROM THE FIRST CAME MANY EUROPEAN ALPHABETS, FROM THE LATTER THE MANY INDIAN ALPHABETS. THE DEVELOPMENT OF SOME OF THE CHARACTERS TO SANSKRIT IS SHOWN ABOVE.

The alien race progressed further than the originating race, just as in historic times the Japanese reduced the 40,000 Chinese ideograms to about fifty syllable characters.

If the Hebrews had not borrowed their alphabetic characters from the demotic, the cuneiform writings developing in Assyria and Babylonia from picturegram to ideogram and phonogram would have become the ancestor of our alphabet.

The simplification of writing gave a great impetus to its use and we find the Semitic tribes and even the neighboring Babylonians using the characters on monuments, seals, gems, weights, coins and papyrus rolls. After five hundred



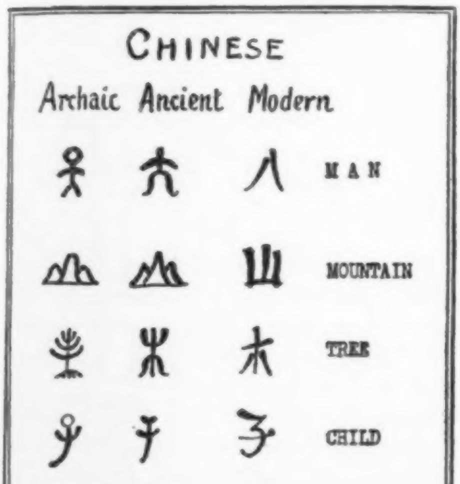
L

THE LETTER L HAS LITTLE CHANGED DURING THE CENTURIES. WE CAN RECOGNIZE IT IN THE SAMARITAN AND HEBREW, THE ARMENIAN, GEORGIAN, SANSKRIT AND THIBETAN. IT IS INVERTED IN GREEK, COPTIC, RUSSIAN, GLAGOLITHIC AND AMHARIC; REVERSED IN BENGALI, PARSI, ARABIC AND SYRIAC; AND SLIGHTLY ELABORATED IN MANCHU, MONGOL, GRANTHA, TELUGU AND TAMIL.

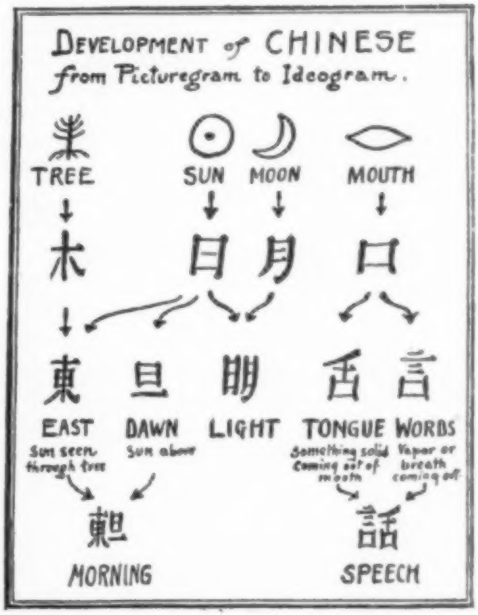
years, around 1000 B. C., fashion and local peculiarities of writing branched into two distinct alphabets, a northern and southern style of writing, which for convenience we will term the Phoenician and Sabaean alphabet. (See family tree.)

The North Semitic or Phoenician Branch

The Moabite stone is among the oldest Semitic inscriptions. This monument was erected around 900 B. C. and tells of the rebellion of Mesha, King of Moab, against the Hebrews. Mesha is indicated in the second Book of the Kings: "And Moab rebelled against Israel after the death of Ahab" (II King, I, 1). The characters of the inscription are crude and resemble those found as Sindjirlie (written around 800 B. C.) as well as



The Chinese characters have developed from pictures, just like the hieroglyphics, cuneiform, Maya and Aztec writings. However, the Chinese have not produced a phonetic writing and the Japanese borrowed about fifty characters for a syllable writing.

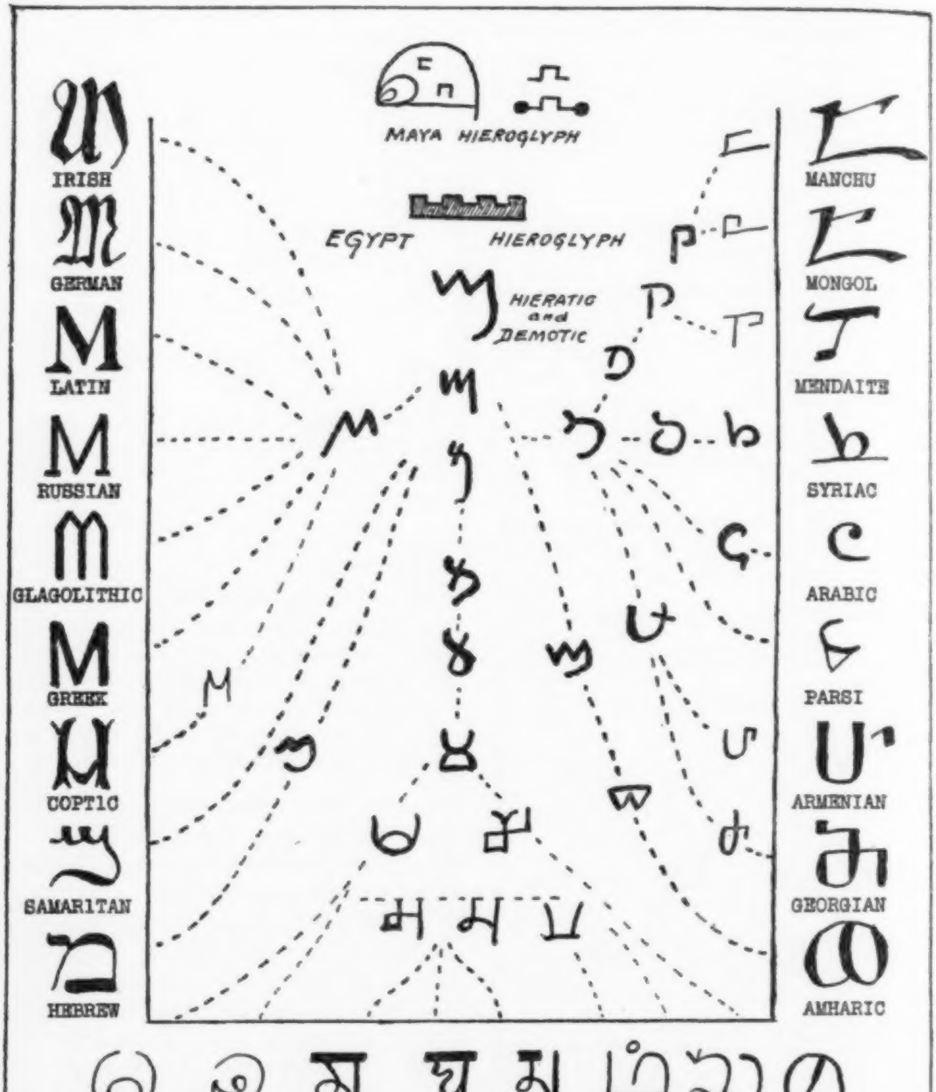


The Chinese tried to step from the picturegram to the ideogram, from the concrete to the abstract, by combining different characters. Thus sun and moon mean "light," the sun behind a tree "east"; east and dawn combined mean "morning."

the rock inscriptions discovered in the tunnel of the pool of Siloam, 700 B. C., which commemorates the completion of a water conduit to Jerusalem.

In the same period falls the rise and decline of the Phoenician city states Tyre and Sidon, who traded over the Mediterranean, reaching as far as Senegal in the south and Cornwall in the north. It was likewise the Homeric age, an indication of the awakening of the Greek tribes, and as the Phoenician traders frequently passed the Ionian and Dorian Islands, they caused there the ripple from which grew the alphabets of the Christian nations, the Cadmean branch on the Phoenician stem.

In the same period—900 to 600 B. C. —the Ethiopian usurpers caused the decline of Egyptian civilization which corresponded to the growth of the military power of Assyria and Babylonia



M

THE MIGHTY M IS ASSOCIATED WITH FORTIFICATIONS, BOTH IN THE EGYPTIAN AND MAYA HIEROGLYPHICS. ITS THREE STROKES ARE DISCERNIBLE IN SAMARITAN, AMHARIC, GEORGIAN AND ARMENIAN. FROM A HEBREW-LIKE CHARACTER DEVELOPED BY SHORTENING AND PROLONGING OF STROKES THE b-LIKE SYRIAC, T-LIKE MENDAITE AND c-LIKE ARABIC, MONGOL AND MANCHU.

and caused the subjection of Jewish tribes. From these changes sprung the Samaritan and Hebrew or Rabbinic form of writing, the alphabets of the Jewish world: the Tyrian branch on the Phoenician stem.

Later came the rise and fall of other empires, the Median, Persian and Macedonian, and they likewise left their imprint in localized alphabets which became the ancestor of Turkish, Arabic, Syriac and other forms of writing of the Mohammedan world, the Sidonian branch on the Phoenician stem.

The South Semitic or Sabaean Stem

Phoenicians were the traders of the north, Sabaeans the traders of the south, and as the characters borrowed from the demotic budded into the Phoenician stem, so the Demotic also grew into the Sabaean stem from which developed many modern alphabets. Phoenicia established the Semitic contact with the Mediterranean and Europe—Saba or Sheba was the Semitic contact point with Africa and India. The Sabaeans traded with the Ethiopians as far back as 1000 B. C. and with the trade came the art of writing and the keeping of records.

According to traditions the Abyssinians are the descendants of the Ethiopians and their royal family claims descendants from Menelik, the son of the Queen of Sheba. This Queen was an extensive traveler; she visited Solomon in Jerusalem and may have also resided in Abyssinia, thus bringing with her court and with traders the Sabaean writing to Ethiopia. Here the Sabaean developed into the Ethiopian branch, which survives in the modern Abyssinian or Amharic alphabet.

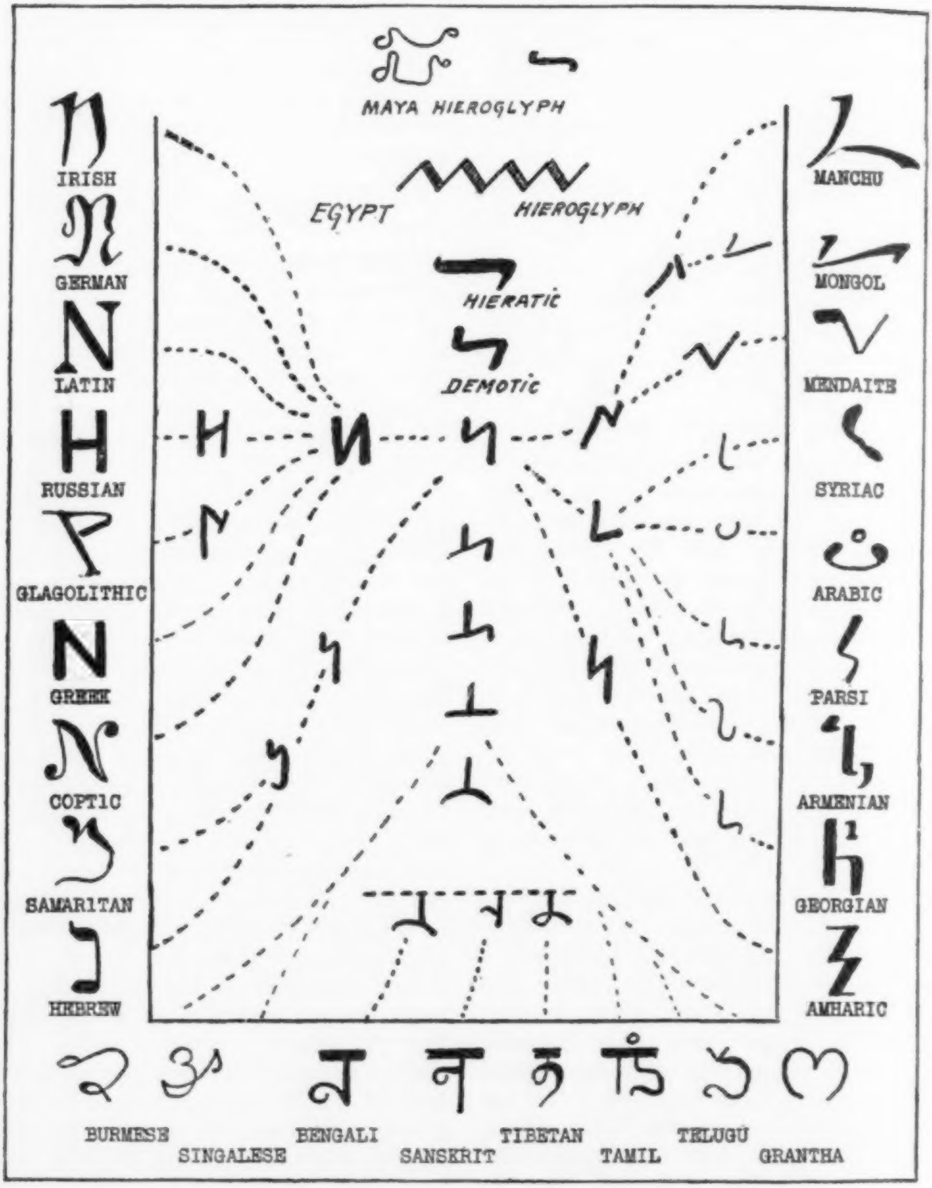
From the shores of India came the Dravidian sailors and with them Sabaean traders ventured to India and brought their way of writing, which became the "Brahmi lipi" and formed a crude embryo of the numerous alphabets of India, Siam and the East Indian islands. However, the Brahmi branch received later a new impetus and reinforcement from the Phoenician stem by the travels of Darius and Alexander the Great.

Why the Alphabetic Characters Change

Before following the development of the different branches of alphabets in our family tree we must know the reasons why individual symbols are subject to change in appearance as well as in phonetic value. Why are they distorted, turned around and upside down, made more fanciful, rounded or squared?

One cause is the combination of materials used for writing, for the material written upon may be stone (monuments and caves), metal (coins, seals, weights or utensils), wooden tablets (records and letters), clay tablets, skins, papyrus or parchment, while the tool used for writing may be a chisel, stylus, knife, reed, brush, stick, feather or pen. By combining these two materials used for writing we find in general two forms—the monumental writing with straight lines, sharp corners and usually carefully executed by carving or engraving, and the cursive writing with curved lines, rounded corners and usually hastily painted or written.

Another cause is the succession in which the letters follow each other. At first the line of letters following each other was continuous and may be in the form of a spiral around a vase or stone pillar, or in zigzag form across the surface of a rock or piece of papyrus, first from right to left, then from left to right. This naturally produces an inverted form of letter, thus a W may become ≶ or an ʍ. Even to-day we have not entirely overcome this inconventionality, for who has not seen a sign with the S reversed. Later scribes may select one or the other form of letter and standardize it by using it exclusively.



N

THE STROKES OF N ARE OLD, FOR WE SEE THEM IN THE SIMPLIFIED MAYA HIEROGLYPH AS WELL AS IN THE EGYPTIAN HIEROGLYPHS. IT IS PRESERVED IN THE UPPER PORTION OF SAMARITAN AND HEBREW, IN MONGOL AND MENDAITE, IN PARSI, ARMENIAN AND AMHARIC. BY MISPLACEMENT OF THE MIDDLE-STROKE THE H-LIKE RUSSIAN CHARACTER IS FORMED, AND BY SHORTENING OF THE END-STROKE IT YIELDS THE P-LIKE GLAGOLITHIC.

Such examples are numerous in the history of our alphabetic characters.

The direction in which the line is written becomes also conventionalized and uniform, thus (a) from left to right in the European alphabets, (b) from right to left in Hebrew, Turkish, Arabic and others, and (c) from above to below in Manchu and Mongol. This naturally influences the appearance of the letters.

Usually we write above the line; in India the habit was to write under the line and gradually the line became a part of the letter, even when a symbol stood alone. This gives the peculiar aspect to Sanskrit and Bengalese.

The fashion of using a more elaborate character at the beginning of a sentence or word began early in the Middle Ages and is the reason that we have capital and small letters. The capitals were

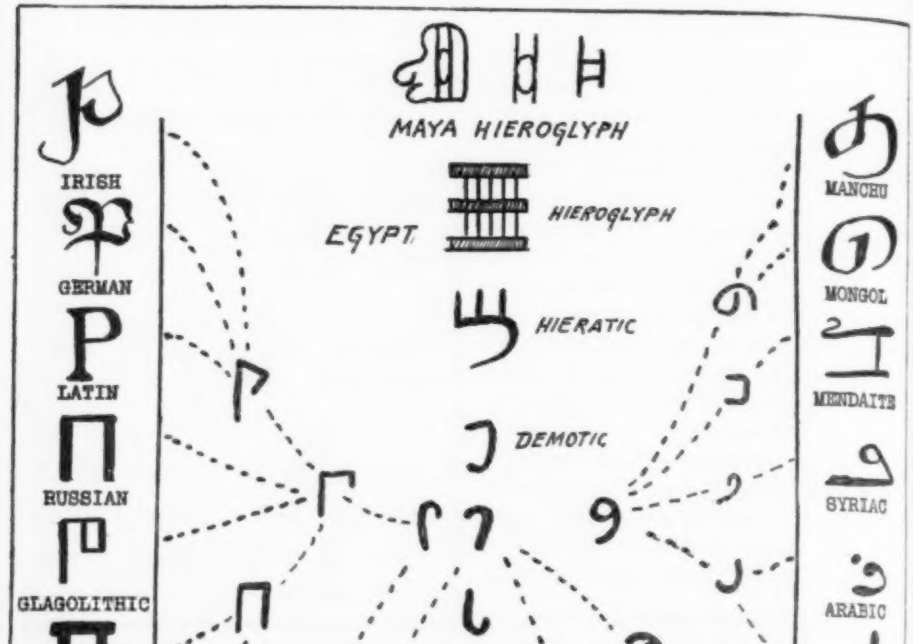
THE OLD MEXICANS DEVELOPED A PICTURE WRITING WHICH GREW INTO A PHONETIC WRITING. WHEN THE SPANISH CONQUERORS CAME AND THE JESUITS CONVERTED MANY OF THE NATIVES TO CHRISTIANITY, THIS WRITING WAS USED FOR THE LORD'S PRAYER AS SHOWN ABOVE: PA-TE NOC-TE . . . A-ME, THE R BEING UNKNOWN TO THE NATIVES.

THERE ARE MANY STRIKING RESEMBLANCES BETWEEN THE SIMPLIFIED FORM OF THE MAYA HIEROGLYPHICS AND THE DEMOTIC OR PHOENICIAN DERIVED FROM EGYPTIAN HIEROGLYPHICS. THIS FACT, AMONG OTHERS, HAS LED TO THE ASSUMPTION THAT THERE EXISTED A COMMON ORIGIN OF BOTH, THE MYSTERIOUS ATLANTIS.

generally selected from the so-called Uncials, a large, ornate and formal script in vogue during the sixth to eighth century among the monks of Central Europe. The small letters came from the Minuscele, a less formal and cursive style of writing developed by the monks in copying and rewriting manuscripts. With the advent of printing more changes came so that we have at least four characters for each letter, type and script, capitals and small letters.

THE CHRISTIAN ALPHABETS DEVELOPING FROM THE CADMEAN BRANCH

We have seen that the Ionian Islands were the contact point of east and west, Greece and Asia Minor. There it was



P

THE P DEVELOPED FROM A HOOK WHICH BECAME SQUARE IN RUSSIAN, GLAGOLITHIC, GREEK AND COPTIC; TURNED UPSIDE-DOWN IN THE INDIAN ALPHABETS; LYING ON ITS SIDE IN SAMARITAN, HEBREW, ARABIC AND SYRIAC; AND TURNED AGAIN IN MONGOL AND MANCHU. THE SIMPLIFIED MAYA HIEROGLYPH RESEMBLES LIKEWISE A P.

that the primitive Hellenic tribes were stimulated to thought by comparison of their ideas with those of the seafaring Phoenicians. Accordingly the oldest Hellenic inscriptions are found on the islands, and among them are those of Thera, which closely resemble Phoenician.

Cadmus, the legendary hero, is merely the personification of the Phoenician influence, and the Greeks adopted with about sixteen characters the Semitic names. Thus, aleph becomes alpha, betel changes to beta, gimmel to gamma, and so on, and even to-day we speak of the ABC as the "alpha-bet."

From the archaic Hellenic forms of writing—the Ionic, Doric and Attic, there blossomed forth the modern Greek, the modern Slavic alphabets, modern English, German and Irish.

Through migrations and travels of the primitive European tribes the archaic Greek writing filtered to the northern barbarians who guarded them as sacred symbols. We find them in the Runes of the North from which came the now extinct alphabets of the Wendes, Goths and Alemans. From the Alemanic grow the Anglo-Saxon and Meso-Gothic, and from the first the modern Irish is derived. In the German and Old English characters likewise are found the influences of these northern alphabets.

The art of writing traveled not only northward, but also westward, for Greek colonists settled in Sicily and Italy and brought the spark of knowledge which gave rise to the Etruscan and Latin alphabets, which ultimately developed into the characters in which this article is written and printed.

Much later another series of alphabets evolved from the Hellenic family. In 863 A. D. Cyrill, the founder of the Eastern Christian Church, came from Constantinople to Monrovia to convert the Slavic tribes to Christianity. At that time the Greek Uncials or large letters were used by the monks and this form of writing was adapted by Cyrill to record the Slavic language. Thus was born Cyrillic, the prototype of Russian Ukrainian, Servian and Bulgarian. Later, when the minuscele, the cursive or small Greek letters, were in vogue, a similar adaptation was made to fit the Slavic tongue, and this alphabet, the Glagolithic, survived until the seventeenth century in the religious books of the Croats, and is in its modern form the Dalmatian and Albanian script.

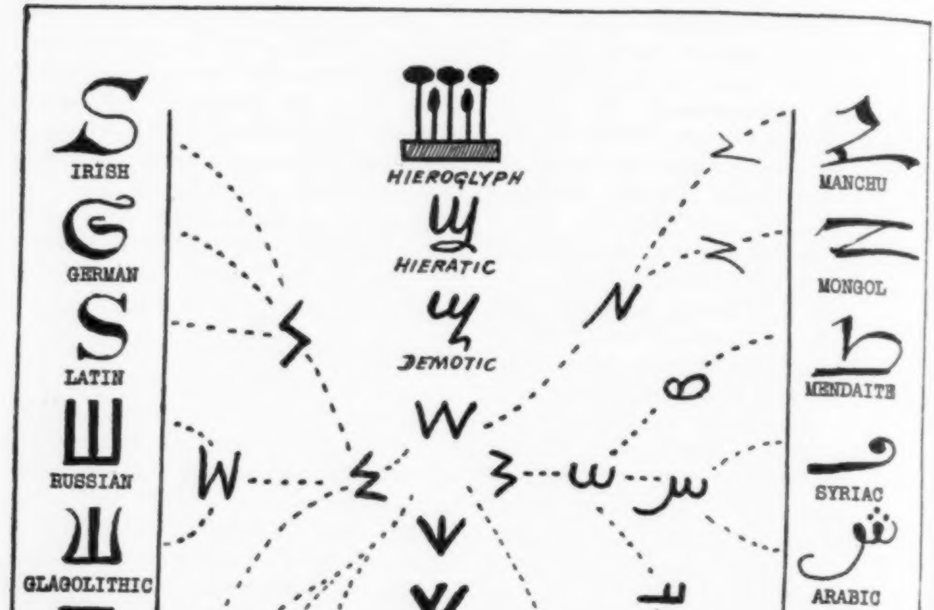
The Jewish Alphabets developing the Tyrian Branch

We turn back again to the Israelites under the Kings and the time of the destruction of Jerusalem and the Babylonian captivity. Previously the Israelites had used the primitive form of writing borrowed from the demotic, but now as they drifted back from exile the Aramaic characters had become popular in Palestine and, indicative of the new start being made, were accepted. Thus the Book of Daniel, 160 B. C., is typical of this form of writing, and these characters became the pattern for the Herodean style used during the time of Christ. Later, about 300 A. D., the characters were "squared" and from the square Hebrew grew the present-day Rabbinic characters.

The Samaritans, however, stuck to the old form of writing which had been used in 580 B. C. before the Babylonian captivity, and from this sprung the modern Samaritan used to this day by a small religious sect in Palestine.

The Mohammedan Alphabets developing from the Sidonian Branch

While the Cadmean branch became associated with the Christian religion and spread over the world, and the Tyrian branch diffused through the world with the Jewish people, so the Sidonian branch travelled far and wide in the wake of Mohammedanism. But long before it became a carrier of religion it played an important part in civilization.



S

S IS ASSOCIATED WITH THE "SH" OF THE RUSHES OF EGYPT, THE HIEROGLYPH OF WHICH BECAME CONVENTIONALIZED TO A W-LIKE CHARACTER, STILL PRESERVED IN RUSSIAN, GLAGOLITHIC, COPTIC, SAMARITAN, HEBREW, BURMESE, SINGALESE, AMHARIC, PARSI AND ARABIC. IT IS LAID ON ITS SIDE IN THE GREEK SIGMA, LOST A STROKE AND BECAME ROUNDED IN THE LATIN AND IRISH S, TURNED THROUGH NINETY DEGREES AND PRODUCED THE Z-LIKE MONGOL AND MANCHU CHARACTERS.

Around 500 B. C. Darius, "a Persian, son of a Persian, an Aryan, king of the Aryans," was a devout follower of Zoroaster and extended the Persian empire from the Black Sea to the Indus, from Thrace to the Punjab. But coming into India he found the Brahmi lipi, introduced earlier by the Sabaeans, and he enforced the use of Kharosti, an Aramaic form of writing which was the fashion among the Persian satraps in all their colonies.

Thus Darius, and later Alexander, created at the crossroads of the Punjab another contact point from which arose another center of civilization and learning.

The Aramaic was principally connected with the Avesta, the book still used by the Parsees, and of which the Zend is the translation or transcription into a modern form of Pahlavi, from which developed the Iranian family of alphabets—modern Persian, Hindustani and Pushti.

A later development of the Aramaic characters is the Hauranitic family, which is associated with the rise of the Arabs and Saracens. Around 500 A. D. we find two forms of old Arabic characters, namely, Nashki or cursive writing, used on papyrus and parchment, and Kufic or monumental writing, used on rock inscriptions, coins and seals. From the first comes the modern Turkish and Arabic, from the later the Syriac.

Nestorian, a patriarch of Constantinople, founded in 435 A. D. a Christian sect, and his missionaries created a wave of Christianity in Central Asia. Their form of writing was the Estrangelo, literally the "writings of the gospel," which still survives in Mendaite, a small sect of Christians in Armenia. The Nestorian missionaries laid also the foundation for the alphabets of the Turkomans and Mongols; Uigur, Manchu, Mongol and Korean. In the transition of Estrangelo to these Asiatic alphabets we witness an interesting turning of the letters, indicated in the illustrations by a dotted line. Instead of writing from right to left, the letters had to be written downward in Chinese style. At first the paper was probably turned through 90°, but in time the characters became modified to suit the new direction and style of writing.

Another Christian missionary, Bishop Mesrobian, was active around 1000 A. D. in what is to-day Armenia, where he introduced an alphabet which "he conceived in a dream," but which is really a mixture of Persian or Iranian with Nashki and Greek. This alphabet developed into the modern Armenian, and in an inverted form into the modern Georgian.

The Coptic Branch of the Sabaean Stem

One of the most interesting alphabets is the Coptic, which has been preserved up to the present day in the least changed form. Many of its characters still resemble closely the ancient demotic characters derived from the Egyptian hieroglyphics. This alphabet is used appropriately by the Copts, the native Egyptians, which have remained Christian in spite of Saracen invasions and have kept their traditions, language and writings in spite of the many vicissitudes.

The Ethiopian Branch of the Sabaean Stem

Just as the Copts have a direct descent from the old Egyptians, so the Abyssinians are descended from the Ethiopians. The courtiers of the Queen of Sheba had brought the first primitive alphabet, and in 100 B. C. the semibarbaric Ethiopians revived their art of writing by borrowing the Meroitic alphabet from the Demotic. This grew into the modern Amharic.

The Buddhist Alphabets Developing from the Brahmi Branch

This large branch on the Sabaean stem is not restricted to Buddhism and India, but includes other religions and coun-

tries, and presents, in its history, a mirror of the complicated and intricately woven history of India and Southern Asia. Two races have always struggled in India, the dark-skinned natives—the Dravidians—and the light-skinned invaders—the Aryans. The battleground was the Punjab at the foot of the Himalayas and at the narrow entrance gate to the great peninsula.

Wave after wave of Aryans came through the northwestern passes and invaded the plains, driving the natives and previous settlers before them into the great peninsula. With each invasion came new blood and a new stimulus to poet and philosopher. Darius had brought the Avesta, Buddha and Mahavira had preached in Magadha, and now came between 264 and 227 B. C. the great Asoka, King of Magadha, who did for Buddhism what Constantine did later for Christianity. Asoka spread the principles of his faith far and wide by many edicts, which are still preserved on stone pillars, on rocks and in cave-inscriptions. All these inscriptions are still a silent witness to the tolerance of Asoka, for they bear the older Brahmi lipi (written from the left to the right) and the newer Kharosti (written from right to left). From these two alphabets developed the many scripts used in India, Ceylon, Burma, Siam and the Malay Archipelago.

There are one hundred and forty-seven vernaculars in India alone, and the alphabets had to be adapted to each particular one. Thus the characters may be found to change their sound when they are traced from one language to the other, but nearly always they modify their shape according to the decorative tendency of the tribe or sect. They may become circles or squared little blocks, simple or ornate with scrolls and curves.

Brahmi was the older, Kharosti the intruding alphabet; hence the first one was held always in greater esteem and it usually furnished the prototype of the Indian alphabets. The development can be followed through the cave inscriptions made during the Kushan Dynasty, the rulers which were contemporary with Christ—followed by the Gupta Dynasty three centuries later, and so on through succeeding dynasties. The simplest grouping of the Indian alphabets is in accordance to their geographical distribution.

The Devanagari family is found in Northern India, where it branches out into the Pali alphabets used for writing the monosyllabic languages in countries as widely separated as Thibet and Siam; the Punjabi alphabets, to which belongs Bengalese, Sindhi and Ghurmuki, and finally the "Sanskrit" alphabets. Sanskrit is a language and as such is written in many different alphabets, including the English, and what we commonly call "Sanskrit" is the Nagari alphabet or "town script," which is generally understood by all educated classes of India and is used in Europe and America for printing the Sanskrit language.

The Nerbuddha or Transgangese family of alphabet has its range in Central India, Ceylon, Eastern India and Burma, and it branches into the Laocian, Tamil, Telugu, Singalese and Burmanese alphabets.

Finally, the Kari or Oceanic family holds its sway over the Mayalan Islands—Java, Sumatra, Borneo, Celebes and even the Philippine Islands.

The Future of the Alphabet

In brief such has been the history of the alphabets. By a slow and tortuous path man has climbed toward the goal of a phonetic alphabet. Nowhere has he achieved this goal, although by a miraculous fate the same raw materials were given to many races and nations. But as progress is bound to continue we shall by and by overcome the inherent inertia and evolve a scientific alphabet—a single character for each sound, and a single sound for each character.

SPIRITUAL VALUES IN SCIENCE

By Professor VICTOR E. LEVINE

CREIGHTON UNIVERSITY, OMAHA, NEBRASKA

Blessings on Science! When the earth seem'd old,
When Faith grew doting, and the Reason cold,
'Twas She discovered the world was young,
And taught a language to its lisping tongue;
'Twas She discovered a future to its view,
And made old knowledge pale before the new.
—*Charles Mackay*

Modern civilization is the resultant of two forces—the old, the inherited spirituality of the past blended with the new, the process of pure science and its applications. A hasty survey of the history of science reveals the remarkable fact that the latter is but of recent potency. The second half of the last century showed greater strides in scientific achievement than all the other centuries put together. Judging pure science from the standpoint of its applications, we certainly must marvel at the great progress made in this field. It is in but recent times that the scientific progress of the world has brought forth the steamship, the locomotive, the automobile and the aeroplane; the typewriter and the linotype; the mowing machine and the harvester; lithography, color photography and moving pictures; the motor, the dynamo and the electric light; the telegraph, the telephone, the phonograph and the radio. In fact, so thick and fast do new discoveries and inventions come upon us that we accept the most interesting and the most ingenious with a degree of calm bordering on indifference.

Science is continually increasing the comfort and happiness of the human race. It has relieved us from the task of pitting our mere physical strength against the forces of nature. It has magnified through the microscope and the telescope man's vision and has revealed to him undreamt-of worlds. Through implements and machinery it has miraculously augmented his physical capacities. Annihilating space, it has made possible the exchange of goods and ideas, and has thus helped to establish a tie of interdependence and a bond of sympathy among the peoples of the earth. It has through antitoxins and disinfectants saved many human lives. It has relieved pain. Well may S. Weir Mitchell sing to the blessings of anesthesia, in his poem, "The Birth and Death of Pain":

Whatever triumphs still shall hold the mind,
Whatever gifts shall yet enrich mankind,
Ah! here, no hour shall strike through all the years,
No hour so sweet as when hope, doubt, and fears,
Mid deepening silence watched one eager brain
With God-like will decree the Death of Pain.

Much has been said and written upon the material aspects of science. Surprisingly little has been the emphasis placed upon its spiritual values. In reality the chief usefulness of science lies not in the material advantages it offers the human race, but in the spiritual enrichment with which it endows the individual pursuer in particular and mankind at large when it makes righteous employment of its applications, inventions and discoveries. What science has to impart to the higher spirit of man we shall presently discuss.

Science sheds brilliant rays of hope upon the future. In the last hundred years tremendous strides have been made through the modern development of sci-

ence in the direction of controlling the physical forces for man's economic needs. The age-old problem of ministering to man's spiritual wants will then have ample time and opportunity to make itself felt as never before in the history of mankind. Present civilization, the outcome of scientific achievement, will then give right of way to future humanization. Life will cease to be one long fever and yearning for possession and conquest, for sensation and excitement. The life of to-day, "a Niagara force without direction, a noise without significance, a speed without accomplishment," will be superseded by the life of the future, which will be alert and not inert, spiritual and not mechanical, religious and not political, mindful of peace and not of power. No longer will there be the breathless rush with which

> We pass and nod and hurry by,
> And never once possess our soul
> Before we die.

As one of the three great tasks that occupy human life Dr. Felix Adler gives the building of our finite world, which, he believes, is accomplished by means of science and its adjuncts. The building of the finite world is not the highest function of science. Its supreme goal is to link nature to man, the finite with the infinite, the self with the non-self; to emphasize the relation of one to all, and to show the unbroken continuity of the inner with the outer world. The current of life which runs through our veins night and day flows through the stem and the leaf and the flower, the rivulet and the mighty ocean. The song of the world and the "music of the spheres" both give expression to the divine harmony. The beauty of nature and the noblest work of man are but different notes necessary to give completeness to the divine symphony.

What is the end of man? It is the realization of the infinite in him. The finite represents the road by way of which man is to rise to spiritual power. The struggle of life is but concrete representation of the tension which accompanies the attempt to pass beyond the finite. Only through nature can the human spirit attain realization. The earth and its forces are not merely physical phenomena to be looted and then left aside; they are essential to the attainment of the ideal of perfection, just as every note is necessary for the attainment of musical harmony. The true scientist sees in natural facts not merely foundation stones for hypotheses, theories and laws, or dumb-bells for mental exercise, but the universal pattern, the spiritual significance. The scientist travels along the path of the finite in order to arrive at and pass through the gates of the infinite.

The true scientist has the poet's attitude toward life. Since poetry can not fulfil its purpose unless it embodies philosophic vision, unless it offers an interpretation of life and gives a fuller view of reality, the scientist must also possess the philosophic attitude toward life. The beauty and order of the world are recreated alike in the vision of the poet and of the artist, in the mind of the philosopher, and in the laws formulated by the scientist. The aim of the poet, of the artist, of the scientist, and of the philosopher is to reveal life within things, the soul within matter; to mirror life not at its surface, but at its deepest roots. The poet and the artist worship God as the spirit of beauty; the philosopher and the scientist pay their homage to God as the ideal of truth. Philosophy is the temple of truth; poetry and art, the shrine of beauty; science, the holy law. Science and philosophy seek truth; poetry and art seek beauty. There is no opposition between the two, for beauty is truth and truth is beauty. Goethe expresses this fusion in lines translated by Carlyle:

> As all Nature's myriad changes still one changeless Power proclaim

So through Thought's wide kingdom ranges
one vast Meaning e'er the same;
This is truth—Eternal Reason—that in beauty
takes its dress,
And serene, through time and season, stands
complete in righteousness.

Starting from different points philosophy and science and poetry travel toward the same destination. They approach reality from different angles. The philosopher and the scientist grasp the synthesis which gathers together all the aspects of the universe. The poet and the artist aim at catching the vision which sees things of beauty of the world as a whole. The goal of each is to formulate a theory of the universe.

The human soul to rise to heights of poetic rapture or scientific vision should become attuned to the soul of things beyond. The inner and outer self must melt into one sweet harmony, for poetry and science echo the melody of the universe. Poetry, or art, or science, or philosophy can be achieved only by a mind at rest, at peace with itself. Poetry, art, science, philosophy, express rhythm of life and harmony of soul. That individual can not be a great poet, a great artist, a great scientist, or a great philosopher, who is ill at ease with the world, who believes it given up for lost, who sees an irreconcilable breach between evil and good, between inferiority and superiority, who looks upon an ideal as something beyond the realm of accomplishment. The poet, the artist, the scientist, the philosopher must have a love of nature and creation and must have faith in the soul of the universe. He must regard it with disinterested affection, not only for the joy it gives, but also for the concept it develops of a higher spiritual life.

The true poet, the true artist, the true scientist, the true philosopher must hear harmony in the Babel of so-called nature and must see uniformity in manifold and seemingly perplexing diversity. The poet and the artist are convinced that the end of all is peace and atonement, and not discord and despair. The scientist is just as strongly convinced that all discord is harmony not understood. Philosophy and science make the world rational and orderly; poetry and art make the world beautiful and harmonious. Disorder and irrationality, philosophy and science can not accept. Discord and ugliness, poetry and art can not tolerate. In poetry and art, philosophy lives; in science, poetry and art, philosophy takes on flesh and blood.

Since science is tinged with poetic vision and philosophic insight, it helps to reveal and intensify the spiritual side of man. It seeks beauty and truth in the manifestations of nature and introduces that philosophical spirit, that spirit of discernment which submits everything to reasoning, condemns ignorance, destroys error, and dispels prejudice. It thus raises the intellectual level and moral sense, and with these strengthened, the ideal of divinity takes full possession of the soul. The poetic genius of William Wordsworth gives most adequate expression to the wholesome inspiration of communion with nature:

For I have learned
To look on Nature, not as in the hour
Of thoughtless youth; but hearing oftentimes
The still, sad music of humanity,
Nor harsh nor grating, though of ample power
To chasten and subdue. And I have felt
A presence that disturbs me with the joy
Of elevated thoughts; a sense sublime
Of something far more deeply interfused,
Whose dwelling is the light of setting suns,
And the round ocean, and the living air,
And the blue sky, and in the mind of man;
A motion and a spirit, that impels
All thinking things, all objects of all thought,
And rolls through all things.

And the poet continues to pour forth the joyous recognition of the debt he owes to the uplifting influence of Nature:

Therefore am I still
A lover of the meadows and the woods,
And mountains; and of all that we behold
From the green earth; of all the mighty world,
Of eye, and ear,—both what they half create,
And what perceive; well pleased to recognize
In nature and the language of the sense,
The anchor of my purest thoughts, the nurse,
The guide, the guardian of my heart, and soul
Of all my moral being.

Nor is the poet alone capable of richness of spiritual vision. Let us hear from a geologist, John C. Merriam, who set forth in the January issue of the SCIENTIFIC MONTHLY, 1921, in the following words:

> One does not expect a geologist to state his views on philosophy in phrases aiming at the deeper human understanding, and yet there seems reason for feeling that the wider outlook of science in all of its aspects lifts us up to the identical viewpoint from which the philosopher and the poet obtain their comprehensive vision. Unlike the philosopher we do not reach backward to explain the origin or forward to interpret the ultimate purpose of Nature; nor can we, like the poet, picture in words with fullness of meaning the view which opens to us, but the type of landscape spread before us and the training of the eye which sees it give to our picture a measure of reality which its stupendous magnitude does not lessen. Of all favored men the geologist and the paleontologist see the panorama of the past unrolled in clearest reality. To them the life record is not written in doubtful hieroglyphics and symbols. It represents the imprints of living feet that have never ceased to advance in unbroken procession over a trail that winds upwards through the ages. From one glimpse at footprints on the sands of time, a poet in the person of Longfellow gave to all generations a Psalm of Life, which has found response in the ever widening circle of human hearts. Pointing in the same direction, but of infinitely deeper meaning than the lines of the poet, is the reality of the story, the sermon, the poem which the geologist sees, which must of necessity reach its recognition through his eyes and its expression through his voice.

The true scientist has the religious attitude towards life. Whenever we find a devotion which makes the finite seem as nothing and some reality to which it attaches itself as all, we have the essentially religious attitude. All such surrenders to unselfish ideals are dedications to higher causes. They abound in the fragrance of the beautiful and carry the semblance of the eternal. A high ideal sets the self free and delivers one from selfishness. Even the common, ordinary, everyday experiences would take us to heaven could we whole-heartedly surrender ourselves to them. The work-a-day world, its things and its events cause trouble of mind and pain of spirit, when we employ them for our own sensation and enjoyment, instead of making use of them for spiritual and unselfish ends. Man's happiness is attained not through getting but through giving himself up to what is greater than himself. In such giving the characteristic traits of religion are ever present.

Selfishness is the unpardonable sin of man. It is his failure to be true to himself. It is the rejection of the divine in him. It is the root-cause of evil and its long train of votaries. It is the fog which obscures his vision and hides his true being. It is the mask that conceals the divine glow in his face. Devotion to an end beyond himself leads to the larger life. If human nature is so limited that absorption into a larger end is impossible, then the fate of man is indeed very pitiable!

The pursuit of science calls forth the spirit of unselfish service. Not only religious movements and movements for greater political freedom, but science also can claim its martyrs. Into the real spirit of science one can not enter without knowing of the failures and successes, of the hardships, trials and tribulations, of the self-sacrifice and self-denial, of the enthusiasm and perseverance of the men who slowly, laboriously, untiringly have added to the ever-expanding storehouse of scientific fact and scientific theory.

Man is distinguished from the other species in creation by his constant conscious endeavor to go beyond his own

physical limitations of self and nature. He has succeeded in removing many of the barriers of an environment to which he no longer reacts passively. He comes to a world which has in the past been created by the will and power of his predecessors. Man is a dynamic force. Freedom of growth should characterize his activities. Freedom of growth implies freedom for creative growth. And when he fails to do his share of creative work, he sins against the self, the infinite, the eternal in him. His salvation lies in forging beyond the circumference of the circle in which he feels himself the self-center. To go beyond this circumscribed boundary, to realize the infinite, he must learn to surrender cheerfully the material, the finite.

This giving up of finite interests dear to man at first involves suffering, hazard, hardship. The steep path to realization is lined with thorns. The infinite is attained only by the brave, the sincere, the back-boned and not the wish-boned, the stout-hearted, the vision-souled. The worth-while in life comes through effort. The worth-while is like oil in the seed. We must apply pressure to obtain the oil; churn milk to have butter; dig the ground to have water. Till the goal is obtained we meet with unforeseen dangers and unavoidable risks. We have to fight with the finite not merely physical wars but spiritual wars as well. All progress comes as a result of giving up and casting off the finite. The young mother, possessed of charms, grace and beauty, throws them all away for the higher pleasure of beholding her first-born. It does not matter if this pleasure comes in anguish at the cost of her charms and even at the peril of her life. The fragrant and bright-colored flower dies for the sake of the fruit, the fruit for the sake of the seed, the seed for the sake of the plant. Struggle and sacrifice are the world's supreme blessings. It is the travail accompanying the birth of a higher soul. It is the attempt of the infinite to break through the dark and narrow womb of the finite.

Professor Elmer V. McCollum, of Johns Hopkins, who has made in the science of nutrition brilliant advances of fundamental nature, once expressed himself to the writer to the effect that he had come to look upon life with singleness of purpose. It is this singleness of purpose that is and will continue to be the unfailing source of his achievements. And it is this singleness of purpose, this whole-hearted devotion to a selfless cause, that is the outstanding characteristic of men of science as well as of men in other human fields of worth-while endeavor, who have left footprints in the sands of time. The great men of science gained their deep insight and far-reaching perspective of the lovely mystery of their calling upon the Gibraltar of character. You have but to delve into the lives of these great personalities to realize the underlying cause of their urge for achievement.

Throughout the ages in every clime, artists and scientists and philosophers have formed a small community isolated from and oft unknown to the great mass of men. They worked on unrecognized and oft under the most trying difficulties. They worked together, as all human beings should, for humanity. While other workers were lost in the maze of competition and bloody jealousy, they understood and practiced democracy and emulation. They maintained themselves by the glow that creative work kindles in the soul, and they kept alive through all the vicissitudes of society the principle of loyalty to the human spirit. In the past they were oft the bright light in the midst of abject darkness; in the present day they are the true aristocrats without whom democracy can not exist. The cultivation of art and science and philosophy and religion in their highest aspects is ever more vitally necessary to the moral condition of the world than material prosperity.

Who shall be called a scientist? Professor Hermann von W. Schulte, dean of the Creighton Medical School, once stated that the highest aim of a medical school should be to turn out young men and young women who would live for the profession and not by the profession. Paraphrasing Professor Schulte's statement of ideals, we may well say that he is a scientist who, possessed of purpose and vision, lives for his work and not by his work. He is a scientist who is saturated with a disinterested love for the universe and whose work is but a revelation of his soul, which exclaims:

I am a part of all that I have met;
Yet all experience is an arch wherethro'
Gleams that untravell'd world whose margin fades
Forever and forever when I move.
How dull it is to pause, to make an end,
To rust unburnish'd, not to shine in use!
As tho' to breathe were life! Life piled on life
Were all too little, and of one to me
Little remains, but every hour is saved
From that eternal silence, something more,
A bringer of new things, and vile it were
For some three scores to store and hoard myself,
And this great spirit yearning in desire
To follow knowledge, like a sinking star,
Beyond the utmost bound of human thought.

When one trained in science turns his work into drudgery for higher wages he can not achieve science. When he neglects the deeper aims of science and allows the canker of commercialism to bore its devastating way into the finest virtues of his calling, he contents himself with evanescent shadows rather than with permanent realities, with chaff instead of with wheat. He is then no more a scientist than the individual who swats flies is an entomologist; than the helper who washes beakers and test tubes, a chemist; than the man who weeds the garden, a botanist. He who is master of technique only is not a scientist. The maker of rhyming lines with a certain number of feet but without any creative idea or spiritual vision is a versifier and not a poet. The product of his efforts is verse, not poetry. Technique is but a link in the chain, and it can not substitute for essence or make up for vitality. Technique alone is like a ship without a rudder, a lamp without light, a violin without music, a religion without faith. Nor is the man with the "dollar" motive a scientist, "who is sorry that the numerous stars in the midnight sky, which hang in the air for no purpose, do not come to earth for the street lighting and thus help the taxpayers."

It is often said that this is a scientific age, and it is frequently believed that science is concerned not with beauty but with cold facts. This is far from the truth. Facts, even cold facts, can not be discovered without the illumination derived from intellectual beauty and poetic vision. Yet how often do we find the discoveries of science utilized, but the spirit that produces them discarded! When the discoveries of science are used with no sense of the larger service they may render, the shadow alone is taken. The age resulting is an age of science exploited. Whenever such conditions prevail no noble use can be made of the powers placed by science in the hands of man.

Science contemplates nature at work and teaches the dignity of labor. Nature is plebeian. It yields no gains without pains. He who would pluck from her vast treasures must go forth and labor.

Errors like straw upon the surface flow,
He who would search for pearls must
dive below.

Hence the logical existence of the laboratory, the workshop which has succeeded in replacing the old idea of authority with the new idea of first-hand knowledge. There the individual, through self-reliance and self-activity, acquires the fundamental basis of his knowledge by discovering truth for himself. There he learns to substitute facts

for appearances and demonstrations for impressions. There he learns from nature, not with the obedience of a slave but with the critical discernment of a judge.

Well may we emphasize the importance of the laboratory by recalling the appeal of Pasteur on learning that work on his own long-looked-for laboratory had ceased:

> If the conquests useful to humanity touch your heart—if you remain confounded between the marvels of electric telegraphy, of anesthesia, of the daguerreotype and many other admirable discoveries—if you are jealous of the share your country may boast in these wonders—then, I implore you, take some interest in those sacred dwellings meaningly described as laboratories. Ask that they may be multiplied and completed. They are the temples of the future, of riches and comfort. There humanity grows greater, better, stronger; there she can learn to read the works of Nature, works of progress and universal harmony, while humanity's own works are too often those of barbarism, of fanaticism, and of destruction.

When we apply the laboratory method, we are struck with the fact that whenever we ask nature a question, we invariably get the same answer, provided we ask the question each time in exactly the same manner. Nature works with regularity, with system. And it is the work of science to discover this regularity by observing phenomena and grouping them according to lines of similarity and of difference. Science classifies knowledge for the purpose of seeking explanations of natural phenomena. And these explanations have been eagerly sought by hundreds of individuals, century after century, oft with no other stimulus than one derived from the feeling and conviction of truth for truth's sake, or with no other motive than the altruistic one of helping forward the march of humanity.

Science impresses the moral lesson that nature works in a spirit of harmony, interdependence, and true democracy. Her results are accomplished with economy, mutual cooperation, and impartiality. Her laws recognize no creed, no race, no tradition, no prejudice. They hold good for the rich and the poor alike. For the individual to be imbued truly with the scientific spirit means, indeed, to breathe the air of undefiled freedom and to saturate his life-blood with an antidote for smallness, narrow-mindedness, and hypocrisy.

Nature idealizes usefulness. Nothing is at rest and nothing stagnates, for nature is dynamic. Every object, animate and inanimate, has its function. Man is not the center of the universe; at best he plays his part. Science impresses him with this fact, humanizes him, and teaches him humility and consideration for fellow-man and fellow-beast. Abraham Coles expresses the same thought in the lines:

> I value science—none can prize it more,
> It gives ten thousand motives to adore,
> Be it religious as it ought to be
> The heart it humbles, and it bows the knee.

Science teaches that "the universe is the manifestation of one grand creative thought, as comprehensive in the diversity of its parts as it is grand in the unity of the whole. These parts have been so wondrously joined and skillfully wrought that each is linked with each, and one with all. In nature's economy nothing is superfluous, and what seems to our feeble vision least important is essential to complete the unity of the plan." In the words of our Longfellow:

> Nothing useless is or low,
> Each thing in its place is best
> And what seems but idle show—
> Strengthens and supports the rest.

As we look into the knowledge so far gathered in relation to natural phenomena, we find that it has become so bulky and complex that it has been necessary to divide it into smaller parcels.

Each such parcel is called a science, and includes more or less a distinct body of knowledge. For the sake of convenience we speak of chemistry, physics, biology, geology, astronomy, although one science at times overlaps the other. In nature there are fine gradations, but rarely abrupt demarcations.

The boundaries between the sciences are arbitrary and tend to disappear as the sciences progress. The principles of one science often find striking and suggestive illustration in the phenomena of another. Thus the most beautiful applications of physics are noted in astronomy, in anatomy and in physiology; the most remarkable uses of chemistry in the field of biology. All sciences gain by mutual support. There are stages in the history of every science when its progress came from applying to its subject-matter wider conceptions of the relations of one branch to another. As a matter of fact, scientific progress consists, for the greater part, in such resorts to a larger synthesis. In the words of James Russell Lowell: "The noblest definition of science is that breadth and impartiality of view which liberates the mind from specialties and enables it to organize whatever we learn, so that it becomes real knowledge, being brought into true and helpful relations with the rest."

The task of discovering particular facts and general laws, of systematizing, classifying, correlating and interpreting has just begun. The astronomer is still engaged in studying the infinitely great. The chemist and the physicist are still investigating the infinitely small—the molecule, the atom, the ion, the electron. The botanist, the zoologist, the physiologist, the bacteriologist are still increasing the rich harvest of interesting phenomena concerning complicated life processes. The psychologist is still delving into the motivity of human action. The embryologist is yet unfolding the first chapters of genesis. The geologist and the paleontologist are still extracting history from the rock of ages. These accumulated treasures, indeed, seem marvelous, and yet, as each year rolls by, we find ourselves, like Balboa, looking down from the mountain top, beholding an infinite and beautiful expanse, yet unfathomed. We feel with Sir Isaac Newton like children gathering shells on the shores of an infinite sea. The vista continues to widen, and new problems, new theories, new viewpoints, loom large before us. To quote Joseph Priestley: "In completing one discovery we never fail to get an imperfect knowledge of others of which we could have no idea before, so that we can not solve one doubt without creating new ones." It seems that

> The unfinished window in Aladdin's tower
> Unfinished must remain.

Shall we therefore give up in despair? By no means. Let us listen to the words of hope uttered by Alfred Tennyson:

> Yet I doubt not thro' the ages one
> Increasing purpose runs,
> And the thoughts of men are widened
> With the process of the suns.
>
> Not in vain the distance beckons,
> Forward, forward let us range,
> Let the great world spin forever down
> The ringing groves of change.

To the investigator in science who chivalrously travels forth to explore the yet untrodden, the work of minute and careful experimentation, close observation and proper deduction seems difficult and at times hopeless. "Oft in the maze, he is hardly able," to use the language of Matthew Arnold, "to see it clearly and to see it whole." But though the roots of science are bitter, its fruit is sweet.

PHYSICAL LAWS AND SOCIAL PHENOMENA

By Dr. R. B. LINDSAY
YALE UNIVERSITY

Of all the phenomena of nature, those presented by the social intercourse of human beings have proved most difficult to cast in the scientific mold. The reasons for this are not far to seek; few phenomena are more complex in their multiplicity of detail, and none are harder to "control" experimentally after the manner of the exact sciences. It was, undoubtedly, just this difficulty of abstracting from the diverse data of society sequences of routine events which could be handled by the scientific method that prevented for so long the growth of a science of society. It was August Comte who first insisted that there really *is* a science of sociology, and, indeed, he considered it the greatest of all sciences, since it includes in its scope all other branches of knowledge. In his discussion of sociology Comte was not content merely to collect and classify observations of social phenomena (in other words, to make a detailed abstract of the available data); he insisted on framing elaborate theories of social phenomena modeled in general after the existing theories in mechanics and physics. This was in line with his positivistic philosophy and led him to carry over into sociology not only the methods but also much of the terminology of the exact sciences. Thus every one is familiar with his social "statics" and social "dynamics," with his social "forces" obeying definite "laws" just as physical forces obey physical laws. More recent writers, particularly Ward, have elaborated these theories, seeking still closer analogy between the social and the physical world. Now I do not question for a moment the great value of using the methods and results of one science in the development of another. Indeed, this is the way all science grows. Nevertheless, in all reasoning by analogy caution is necessary, and it strikes me, as a physicist, that neither the earlier nor the more recent sociologists have been particularly cautious in their use of physical nomenclature. Perhaps some of this has been due to the looseness with which the exact scientists themselves have until very recently treated the terms of their field of work. As an example, I should like to consider the use of the word "force." This originally had a causative significance in physics, but that meaning it has now entirely lost; it now serves merely as a convenient symbol for the mathematical description of the motion and changes in the motion of bodies. This change is in line with the gradually developing conviction that it is no function of science to investigate the "causes" of things, that its purpose is rather to "describe" than to "explain." It therefore seems of doubtful worth to retain the word "force" in social science, for social "forces" do not *cause* social events to happen any more than physical forces *cause* physical events to happen. The use of this word has undoubtedly appeared to give to many elaborate social theories far more validity than they actually possess.

Much the same may be said about the word "law." In carrying over into sociology the physical concept of a "law of nature," it is necessary to understand exactly what is meant by this term. There was a time when such a law was conceived more or less as a command enacted by some divine legislature for all

men to obey. Things went as they were observed to do because of the existence of divine law, which kept them from doing anything else. This element of necessity has, however, entirely vanished from the present-day conception. The modern physicist conceives a natural law to be only a shorthand formula of the mind comprehending a brief description (preferably and in the last analysis in mathematical language) of a large group of sense impressions. Physical laws are never forced on man from without; they are the product of man's own reasoning about his experiences in the world. Needless to say, they are in a continual state of change, as man's experiences widen and grow more diverse. It is impossible for a physicist to conceive of laws of society on any other basis. Like the laws of physics, they can be merely generalizations of the mind subsuming sequences of social events. As our knowledge of the ways of society grows, so too these laws will change.

While still observing carefully the precautions emphasized immediately above, I think that there is a fertile field of endeavor open in the application of physical laws to social phenomena. It seems reasonable that among the laws of the physical universe there may be some of sufficient generality to possess significance for the relations of society. In seeking for such it is well to remember that physical laws may be divided into two great classes generally denoted by the terms *macrocosmic* and *microcosmic*. As the words imply, the former have to do with matter on a large scale, in the gross, so to speak, while the latter deal with matter in the little. A few illustrations will serve to make clear the distinction. The Newtonian law of gravitation is a macrocosmic law, for the motions of all gross forms of matter, *i.e.*, matter perceptible directly to the senses, appear to be governed by this law. When we come, however, to the ultimate infinitely small atoms and electrons out of which modern physics supposes matter to be constructed, we find that their motions can no longer be exactly represented by the Newtonian law. New laws, new formulae are needed to describe the latter, and these are termed *microcosmic* laws: they deal with phenomena on a very small scale. Furthermore, the law of the conservation of energy, which teaches that the total amount of energy in the universe is constant and that all we can do is to transform it from one form into another, is a macrocosmic law, while the law or laws governing the interchange of energy among atoms and molecules are microcosmic laws. In other words, we conceive the atom as the microcosm, so to speak, and the gross material as the macrocosm.

Now under which of these two classes will the laws of social relations fall? Is it not clear that while the individual person is the social microcosm, the social group is the macrocosm? When we look, therefore, for physical laws which are of immediate application to social phenomena, we are inevitably led to the macrocosmic variety.

It is not my purpose here to enter on any thoroughgoing investigation of all the analogies existing between the physical and social macrocosms. But I have been led recently to consider one general physical law which seems to be of great significance in sociological theory, and a discussion of this may well serve as an illustration of the kind of field of endeavor opened up by the above considerations. I shall begin with a description of the physical meaning of the principle I have in mind, using first a very humble example.

Every one must have observed that when a bicycle or automobile tire is pumped up rather quickly it soon becomes hot, and the hotter it becomes the harder it is to pump. At first thought there seems nothing more remarkable

about this than the fact that part of the work spent in the pumping reappears in the form of heat, which is unable to escape from the compressed air fast enough for the latter to remain at its previous temperature. But if we inspect this phenomenon more closely we find matter of greater significance. It will be recalled that when a gas is heated it expands, as witness the hot-air house-heating system. We must therefore conclude that the hot air in the tire also tends to expand against the force that is compressing it. To use a more personal mode of expression, we may say that the air *resists* the compression and alters its condition in order to nullify as far as possible the action brought to bear on it; it thereby acts to retard the compressing process and to make it harder to perform.

This simple phenomenon is an example of a very profound law of nature well known to students of physics and chemistry. In technical language it is called the principle of *mobile equilibrium;* for our purposes it might be more appropriately named the principle of inertia, since it expresses so clearly the inertia or reluctance to undergo change which characterizes every body in the physical universe. In order to state the principle in general fashion, I must first make plain what is meant by a physical *body* or *system* of bodies and the *state* of such a system. By the former term physicists denote merely an aggregation of physical particles in gaseous, liquid or solid form, while the state of a system is simply its physical condition at any instant of time, and this is conceived to be determined by a number of factors. Thus we speak of the *pressure, volume* and *temperature* as the factors which fix the state of a gas, since when these are given we know or can determine mathematically all that is necessary to know or indeed all that *can* be known about the gas in so far as it is an object of our sense impressions. So also the *electromotive force, current, resistance, inductance* and *capacity* are the factors which determine the state of an electric circuit, as, for example, a radio circuit.

Now any physical system is said to be in a state of equilibrium when the various factors fixing its state do not of themselves tend to change. What the principle of inertia says is this: if any one of the factors determining the state of a system in equilibrium is altered in any way, the other factors will themselves so change as to *oppose* the change in the first and partially annul it. A system in equilibrium thus betrays a latent but powerful conservatism. It prefers, so to speak, to remain as it is. It detests alteration. We hardly need add that this principle is of the widest generality in nature. Indeed one can hardly mention a single law governing physical or chemical change which does not somehow involve the principle of inertia.

Does it not seem plausible that we have here a law manifestly macrocosmic in character, the application of which extends far beyond the bounds of the natural sciences? As the sociological analogue of a physical system let us conceive of a social system comprising a number of human individuals grouped in a definite way and for a more or less definite purpose. Like the physical system this social system will have its condition defined by certain factors which we may call social factors. Thus the family, the kinship group, the state, are illustrations of what I mean by a social system. Likewise the church and the school. Among the prominent social factors we may include the physical environment, the mental and moral equipment of the individuals making up the system (*i.e.*, their reason, passions, hopes, fears, etc.), and the traditions which the group has accumulated during its existence. These factors are

closely related to the social "forces" of the sociologists, but for the reasons amply set forth above, I prefer not to use this name. I can not look upon them as having causative significance, they are but symbols with which to describe the phenomena displayed by social institutions. They differ from the factors defining a physical system in one important particular, *viz.*, in the majority of cases they are much more numerous and in consequence less sharply defined and less susceptible of precise measurement. To illustrate: we can measure with extreme accuracy the pressure of a gas at any instant, but it is a far more complicated matter to estimate the traditions of a race and their influence on its present state. Nevertheless, the extent of our knowledge of any social system is directly proportional to the exactness with which we are able to estimate the factors determining its condition at any time. In this sense the analogy between physical and social systems is quite complete. But have they no other aspects in common? They have; and it is here that the principle of inertia plays its rôle. A social system, like its physical analogue, is capable of existing in a state of equilibrium, which is, moreover, susceptible to change from without. To be sure, the changes in social institutions would seem to indicate that social equilibrium is of a rather unstable kind. Yet if we study any particular social institution, as, for example, the family, we find great periods during which change, though present, is very gradual and in which, therefore, a kind of equilibrium may be said to be established. These facts are well known, but the really important point which I have never seen emphasized is that while social systems *do* change in time they also resist change. Like physical systems they tend to oppose any alteration imposed from without. When an external influence is brought to bear on one of the factors defining the condition of a social system, the other factors alter to nullify the change as far as possible. Every social system is essentially conservative.

Has it not often seemed strange that all the movements toward social reform which most persons are now inclined to recognize as having benefited the human race, were bitterly opposed, nay, often fought with tooth and nail? And does it not appear equally curious that the great political and ecclesiastical changes which have taken place in recorded history have in almost every case been at the expense of continual wars and untold bloodshed? Yet these are but illustrations of the generalized principle of inertia. No social institution in temporary equilibrium consents to change without resistance, without a struggle. Of the many examples which history affords two will suffice for our purpose here. Let us recall the great efforts of men with broadened minds and liberal ideas to reform the decayed and almost outworn social structure of the French nation prior to 1789. Let us also remember that these attempts led to such vehement opposition to change within that structure that revolution and temporary chaos followed. As another illustration may be cited the attempt to alter the prevailing manufacturing methods in England in the early part of the nineteenth century. The resistance this aroused, the riots and other disturbances which played so large a part in the industrial revolution form an important section in English social history. In each of these cases we see a social system in transient equilibrium opposing change in the factors which defined it.

It is important to note, however, that the inertia manifested by a social system does not enable it wholly to avoid change. Indeed, it is a cardinal fea-

ture of our principle that the system in the very act of resisting change *alters* the factors that determine its state. By this very alteration the system takes on a new guise different from the old; it has actually evolved. Thus we may look upon the essential conservatism of social systems as containing in itself the germ of change, of evolution. In any instance the alteration brought about may be expected to be a compromise between what the external influence would effect if unresisted and the original state of the system. Such compromises are characteristic of every phase of society. At this moment a particularly interesting illustration is afforded by the modern problem of the family.

That the family considered as a social system is to-day in a state of great instability, no one can doubt. Many are the external influences which are affecting it, among these being the freer status of women, the modern feministic movement and the rapid increase of industrialism. These conditions have been working slowly for some time, and for this reason the inertial resistance to them is not so evident. A more radical blow at the family is the quite definite movement on the part of the communistic theorists to abolish marriage altogether, substituting for it free love or what amounts to promiscuity in sexual relations. Experimentation in this direction is already taking place in Russia. If we may accept as reasonably correct the accounts reaching us from that country, the resistance which this movement is arousing, particularly among the peasantry, bears witness to the innate conservatism of this institution. The family is not yet dead nor will it wholly die. At the same time the resistance to change is causing a modification in this institution which will mean a genuine evolution in its character. The social evils already attending this attempt to subvert the older marriage relation, the most serious of which is doubtless the utter degradation and ruin of childhood, will act to bring about a different attitude toward the family—whether more wholesome than the old is for philosophers to discuss. What we may be sure of is that there will be definite change succeeding the present chaos.

By this last illustration we are brought to another important aspect of the principle of inertia. In physical changes the more rapidly the external influence attempts to work, the greater is the resultant resistance and the greater is the amount of work which must be expended to overcome it. To revert to our original simple illustration, the *faster* we try to pump up the bicycle tire, the hotter it gets and the more difficult we find the task. In the same way every one must have noticed that it is harder to open a heavy revolving door *rapidly* than it is if one is content to do it slowly. Likewise in social phenomena, the more radical and impetuous the reform sought in a social system the greater is the opposition aroused and the more difficult it is to overcome this opposition. Conversely, a more deliberate change is not so hampered. In our comments on the present state of the family we saw that the influences operating most largely (at least in our own country) to bring about change in this institution are proceeding so gradually that the resistance to their action attracts less attention and indeed needs careful analysis to detect it, while the more radical Russian movement is arousing correspondingly radical opposition, with the consequent chaotic results so evident to observers in that country.

The principle of inertia thus leads us here to glimpse an extremely significant generalization regarding all changes in social systems. This affirms that development in society, like development throughout all the natural universe, in

so far as we are able to observe it and its effects, proceeds with extreme slowness, that there is no more real basis for a cataclysmic theory of society than there is for a cataclysmic theory of natural phenomena as a whole. Even the occurrence of revolutions and other upheavals, which may seem at first thought to give the lie to this thesis, really do not contradict it; such events are but the inevitable turbulences in the flow of social phenomena. No one will deny their contribution to the development of society, but the important point is this: the changes which they seek to bring about all at once actually prove to require years for their maturity. All this is bound up in that very resistance to alteration, that innate inertia which is a fundamental characteristic of all social systems.

Many of us are apt at times to grow pessimistic over the wave of radical reform propaganda which threatens to engulf our already much buffeted institutions. May we not extract a grain of comfort by meditating on the principle of inertia? No social system has ever been completely overturned all at once and the probability is relatively enormous that no social system ever will suffer this calamity. Changes there will be and great ones, but they will come slowly; all efforts to accelerate matters will meet the same fate as in the past—stubborn resistance and decelerating opposition. If the doubter asks why this should be so, I can say only that it is not within the province of science to answer this question. The "why" belongs to metaphysics; science is content with the "how." But the practically minded doubter may yet counter with the accusation that our contemplation of the principle of inertia is unethical, since it may cause people to shirk their social responsibilities under its comforting shelter. This again is a matter for the philosopher to settle. I can state only that our principle has no power to "cause" anything in the metaphysical sense. It is a generalization of experience and describes briefly how things appear to go. I must confess my feeling that in it we catch a glimpse of a law of nature transcendent in significance. I believe no science of society can afford to neglect it.

CREDULITY VERSUS SCIENTIFIC DEMONSTRATION

By T. SWANN HARDING

BELTSVILLE, MARYLAND

In the early seventeenth century Nicholas Culpepper, "Gent, Student in Physik and Astrology," published "An Astrologo-Physical Discourse on the Vulgar Herbs of this Nation; Containing a Compleat Method of Physick, Whereby a Man May Preserve his Body in Health or Cure Himself Being Sick, for Three Pence Charge, With Such Things Only as Grow in England, They Being most fit for English Bodies." It is superfluous to add that long titles were not unfashionable in those days.

In this really remarkable work Culpepper recommended arch-angel (not Gabriel, but the weed sometimes called dread-nettle) to make the heart merry and to drive away melancholy. He extended a balm to cause the mind and heart to become blythe and prescribed motherwort to drive melancholy "vapours" from the heart. He sapiently remarked, "the chief use of them is for women, it being an Herb of Venus and may be found in the guide for women. Balm is a herb of Jupiter. Mother wort is owned by Venus."

All this was offered for three pence. But we advanced humans of to-day are quite incredulous. We may pile up a hundred thousand dollars annual profit for a fakir who dispenses snake oil for rheumatism or for deafness. The substance may consist of the oils of wintergreen, eucalyptus and neatsfoot combined with camphor, mustard and benzol. The snake may be altogether absent and the oil demonstrably impotent against whatever is meant by rheumatism or in helping deafness. But we enrich the manufacturers.

Or we may believe in Arthur Crane, "The Great Exorcist," who, prior to 1920, became wealthy by bidding his clients to direct their minds toward him at specified times when he consented (for value received) to be receptive, and to say, "I am unloading all my cares upon Arthur Crane." Thousands prayed, and paid, and were cured and, until an inhuman postoffice department interfered, Arthur prospered. Nevertheless, we have advanced. Certainly we are very incredulous regarding such phantasies as that of Culpepper, Gent.

But legitimate scientific research of undoubted authenticity tends constantly to strain our credulity. There is a form of ice which can only exist at a temperature of 175° F. and under a pressure of a hundred tons to the square inch. What can we do about that demonstrable fact except believe and let credulity go hang?

Nothing seems more prosaic than the segment of science which concerns itself with the nutrition of cows and goats. The cow is, to be sure, a placid and virtuous animal but is certainly not one to get excited over; and, whatever may be said for the goat, it does not readily lend itself to lurid and fantastic speculations. Yet right here there is the positive thrill of the almost incredible, which is none the less the experimentally demonstrable. Moreover, since all such investigation upon lower animals has its ultimate application to the biped permitted by an indulgent fate to abuse a very attractive planet, these findings have human importance as well as human interest.

Although our subject is not these too volubly discussed entities called vitamins, we shall have to mention them in passing to lead up to our subject. The vitamins are, just now and before they have a chance to be renamed, fat soluble A, promoting growth and essential to the young, water soluble B, the antineuritic and growth-promoting, C, the antiscorbutic, fat soluble D, the antirachitic and again essential to the young, and E, the reproductive vitamin Evans discovered. Though discussion has raged and claims have been made in unprofessional profusion, Funk's statement on "Who discovered Vitamins" in *Science* for April 20, 1926, probably apportions the credit as equitably as it can be apportioned.

Many investigators, for instance, Drummond, Channon and Coward (*Biochemical Journal,* Vol. 19, p. 1047, 1925) accredit the discovery of vitamins to Sir F. Gowland Hopkins, of Cambridge University. In 1906 Hopkins noticed that experimental animals died on a diet which was chemically adequate. He then said, "But further, no animal can live upon a mixture of pure protein, fat and carbohydrate, and even when the necessary inorganic material is carefully supplied the animal still can not flourish." He suggested that accessory food factors, then unknown, are necessary to maintenance and growth.

Hopkins's statement does indicate unusual perspicacity, but it is speculative rather than directly evidential. As a speculation it was not an early one. As Van Leersum notes in *Science* for October 8, 1926, Pekelharing, professor of physiological chemistry and histology in the University of Utrecht, made a similar observation in an address to The Netherlands Medical Association in 1905. And Bunge had the idea as early as 1891.

Said Pekelharing: "There is a still unknown substance in milk which, even in very small quantities, is of paramount importance to nourishment." Said Bunge, doubtless with reference to Lunin's work in his laboratory in 1888, mice "are unable to live on proteins, fats, carbohydrates, salts and water," for "other substances indispensable for nutrition must be present."

Casimir Funk himself recognized the existence of vitamins, comprehended their real importance in nutrition, made the first chemical study of B and acted as a catalyst to further investigation. Credit must really be divided among many workers—Bunge, Stepp, Röhmann, Eijkmann, Schaumann, Suzuki, Pekelharing, Hopkins, Evans, McCollum—to name a few.

But enough of history, though it is interesting to get it properly straightened out. What are these vitamins? As reference to any recent work on nutrition will show their discovery completely demolished much earlier work on animal feeding which had been assumed correct for all time. What motivates these vitamins? How do they work? Are they obscure catalysts like enzymes?

Enzymes have long been obscure organic bodies capable of enormous amounts of work. Thus invertase can split fabulous quantities of cane sugar into its two constituent sugars, glucose and fructose, and it never tires. Once successfully extracted from the solution of the simpler sugars which gradually impede its progress, the invertase, however elusive, is ready to do just as much work over again as often as you like. Its capacity is infinite. Zymase, rennin, pepsin, thrombin and other enzymes are similar mysterious prestidigitators—long perplexing science.

But at last *Science* for November 12, 1926, reported the actual crystallization of an enzyme by Dr. James B. Sumner. It is urease, which converts urea into ammonium carbonate, to the great advantage of vegetation. It proved to consist of octohedral crystals slightly larger than blood corpuscles. It is a protein. Yet vitamins yielded to crystallization even earlier than enzymes.

At least *Science,* in the issue for November 14, 1924, carried Atherton Seidell's account of his crystallization of a vitamin. He gave a history of previous work and then described the isolation of a solid crystalline material of definite melting point which had the properties ascribed to vitamins A, B and D. He stated that vitamins are not enzymes. The isolation of a crystalline substance uniformly marks a great advance from the standpoint of chemical research. Yet there remain mysteries that even vitamins do not seem adequately to explain. Indeed, these new scientific strains on our credulity seem more likely to explain the vitamin mechanism than the other way around.

During recent years the science of nutrition has tended to curious quirks which would have horrified orthodox scientific investigators only a few years ago. So strange are the implications of these new discoveries in nutrition that they sound like heroic journalism rather than sober articles in the *Journal of Biological Chemistry,* which Haldane rightly says "one reads at one's leisure."

It has long been known that if a cow, for instance, be fed a ration deficient in the classic elements of nutrition—protein, carbohydrate and fat—this ration is injurious. But more recently a number of research investigators have shown that mineral elements, like calcium and phosphorus, which occur in the ration in very small quantities, play a rôle of unexpected importance. It has been fairly well established that cows fed upon a ration deficient in calcium abort readily, give a decreased milk yield and become predisposed to pathological conditions of obscure etiology.

Thus timothy hay, which is deficient in calcium, will, if used exclusively for the animal's roughage along with a grain ration ample in all other constituents including phosphorus, not only cause faulty assimilation of calcium but of the phosphorus as well. It thus acts injuriously. It is obvious, then, from the standpoint of the older chemistry, that all one needs to do to make timothy hay a satisfactory food is to add an appropriate amount of some soluble calcium salt. This is precisely not the case, though.

Timothy hay with an artificially added mineral supplement to atone for its calcium deficiency remains an unsatisfactory feed. Alfalfa hay, containing about one and one half per cent. calcium (in lieu about .3 per cent. for timothy) is satisfactory, if properly cured, but if improperly cured, alfalfa is also unsatisfactory, regardless of its calcium content. In the light of the older chemistry such a phenomenon is mysterious, unless we call to our aid a catalyst—a substance which will by its mere presence cause chemical action in two other substances without itself entering chemically into the reaction at all.

For years catalysts were great mysteries. To-day they are being very gradually explained. The timothy-alfalfa problem has, however, not yet been solved. But the term vitamin may be used to designate the activating agency which rendered properly cured alfalfa so nutritive. Of course the calcium in the poorly cured alfalfa may occur differently combined chemically from that in well-cured alfalfa. Or it may differ in its physical state. But more likely the presence or absence of a vitamin causes the result that we observe. Yet another more extraordinary explanation suggests itself and there is ample experimental evidence to give it considerable foundation.

Rats and human beings are subject to a disease associated with vitamin and calcium deficiency called rickets. Faulty calcium and phosphorus metabolism cause this disease. Cod liver oil is antirachitic in that, by its vitamin content, it so regulates utilization of calcium and phosphorus by the body that normal health and growth may be maintained on a diet actually deficient analytically in these two elements! As the *Journal*

of the American Medical Association said editorially, it is most extraordinary that a substance containing neither calcium nor phosphorus will enable the body so efficiently to utilize grossly deficient amounts of these two elements that the individual retains normal health. But this is a demonstrated fact.[1] The anti-rachitic and growth-producing properties of cod-liver oil have therefore been presumed to be due to a vitamin.

Then Steenbock, of Wisconsin, began to feed certain rats cod-liver oil in order to improve an otherwise deficient diet. These rats were kept in a cage together with others which did not have the necessary cod-liver oil supplement. To his amazement the rats which were not fed the oil retained their health and grew normally, quite like the others. Finally he remembered that all the rats were exposed each day to the light of a mercury vapor lamp and also that Huldschinsky had, some years before, demonstrated that rickets could be cured by exposure to the ultra-violet rays from such a lamp. This was significant.

When the rats were separated and none of them exposed to the lamp or to sunlight, those not fed the oil became rachitic. If, however, the poorly fed rats were exposed for a few hours daily to sunlight or to the mercury vapor lamp, thus irradiated, they remained in normal health. More curiously still, if the rats which were irradiated were then permitted to associate with unirradiated rats on a deficient diet, the latter also remained perfectly normal. Finally, it was found that if an oil, like linseed oil, which is not normally anti-rachitic, was irradiated with sunlight or light from the mercury vapor lamp, it acquired anti-rachitic properties.

This indicated that vitamin properties, or vitamins, were sometimes generated photo-synthetically—by light—just as sugar is manufactured in plants. Steenbock sent an early, preliminary report of his work to *Science*, where it appeared September 5, 1924. Immediately Hess, of New York, wrote to *Science* (September 19, 1924) confirming Steenbock's work, but claiming priority on his part. He too had irradiated various oils and had found them anti-rachitic when fed.

Hence vitamin D effects are present in hitherto inert oils after they have been exposed to ultra-violet rays. Hess also found that he could easily activate the important human fat cholesterol and impart anti-rachitic properties to it. This is significant because cholesterol occurs prominently near the surface in the animal organism and its analogue, phytosterol, is similarly prominent in the vegetable world and can likewise be activated by light. Neither fat is normally anti-rachitic. Later still the anti-rachitic part of an oil or fat could, after its irradiation, be separated from the rest of it and shown to be a chemical entity.

Further investigations on the irradiation of cholesterol led to the separation of the irradiated substance, by fractional precipitation, into an anti-rachitically active oil and an inactive portion, presumably unchanged cholesterol. This was done both by Koch and coworkers

[1] This is from the *Journal* of the American Medical Association, Vol. 83, page 1169. To be strictly exact it must be added that in 1925 apparently reliable work by H. C. Sherman (*J. Biol. Chem.*, LXIX, pp. 429–461) showed that cod liver oil alone would not render the body calcium of rats normal on a low calcium ration; to effect this calcium lactate must be fed in addition to the cod liver oil. The incident will illustrate the dangers of attempting to abstract science progress popularly in definite terms. This work of Sherman's also leads to the reflection that while vitamin D and ultra-violet light may be very essential factors in healing rickets and do very materially affect the calcium and phosphorus content of the blood in that disease, other factors may act also to control calcium metabolism in a normal animal with a normal blood calcium and phosphorus, *e.g.*, a lactating cow. This view is sustained by the fact that cod liver oil added to the ration has not, on certain occasions, put a lactating cow in positive calcium balance, (Meigs, Turner, Harding, Hartman and Grant, *J. Agr. Research*, XXXII, pp. 855 and 859).

in Chicago, and by Hess and coworkers, in New York. About 5 per cent. of the anti-rachitically active oil was gotten. It differed chemically and physically from cholesterol. Still more recently, 1927, Hess has questioned whether pure "cholesterol itself developed anti-rachitic properties through ultra-violet light irradiation, or whether it is not rather some contaminating substance intimately associated with it which acquires this specific property."[2] Here the matter rests at this writing—early March, 1927.

About this time Kugelmass and McQuarrie, of Yale, published also in *Science* a note saying that rays emitted by cod-liver oil would fog a photographic plate with a quartz, but not a glass, plate between. Ultra-violet rays can penetrate a quartz but not a glass plate. The indication was that cod-liver oil emitted such rays and that perhaps their liberation in the body when cod-liver oil was taken accelerated or activated calcium and phosphorus metabolism.

Unfortunately, however, it is necessary in the interests of strict veracity to add a damning fact of the type usually omitted in records of scientific progress as prepared for non-scientists. Schlutz and Morse in 1925 (Proc. Soc. Exp. Biol. Med. 22, 555) could not confirm the findings of Kugelmass and McQuarrie. They passed a slow stream of oxygen over the surface of some cod-liver oil in darkness and left the photographic plates exposed to it for sixty-six hours. In spite of the fact that the cod-liver oil was high in vitamin activity, the plates were not fogged. Here this matter rests just now.

In 1926 Weston A. Price reported at the spring meeting of the National Academy of Science in Washington that he found calcium deficiencies improved by rubbing cod-liver oil on inflamed joints. This would indicate absorption of a therapeutic agent through the pores, a thing long contested in medical journals, which have but recently published other evidence that such absorption does sometimes take place. Price found that the calcium content of the blood stream was increased by such application of an oil containing no calcium whatever. Chickens on a deficient ration could be kept in perfect condition by rubbing them with cod-liver oil. While this work remains so far unconfirmed it is extremely interesting and suggestive.

In the December, 1925, *Journal of Biological Chemistry* appeared another notable contribution to the subject from Hart and Steenbock. They demonstrated that exposure to ultra-violet light influences calcium and phosphorus storage in lactating goats. Exposure of the goat to a mercury vapor lamp for twenty minutes a day changed a negative to a positive calcium balance; *i.e.*, the animal stored rather than lost calcium. This was done on a ration manifestly deficient in the anti-rachitic factor. They concluded that sunlight is probably more important to calcium and phosphorus assimilation than is green plant tissue. In 1927 they found, however, that a cow did not react similarly to irradiation by ultra-violet light; its calcium and phosphorus metabolism and its milk yield remain unaltered (*J. Biol. Chem.*, May, 1927, p. 59).

These workers at the same time showed that milk can be rendered anti-rachitic by ultra-violet irradiation, another case of synthesizing a vitamin. Luce (*Biochem. J.*, 18, 716 and 1229, 1924) also showed that the milk of pasture-fed cows had a definitely higher anti-rachitic

[2] Proc. Soc. Exp. Biol. Med., January, 1927, XXIV, 369. It was hinted in the same publication (XXIV, 461) that since irradiated ergosterol brought about healing of rachitic bones when but .003 mg of it per capita was fed daily to rats, it might possibly be associated with cholesterol in the body and cause the effects hitherto attributed to irradiated cholesterol. This work is by Hess and Windaus. Rosenheim and Webster, in Great Britain, also activated cholesterol with ultra-violet light and separated the active fraction (*Biochem. J.*, 20, 537, 1926).

value than milk of the same animals stall-fed on a winter ration of roots and cereals. In testing such milk on rats it had to be remembered that a lack of Vitamin D inhibits growth as well as causing rickets. In later experiments D was supplied to the rats by feeding irradiated vegetable oils, but no A was supplied. Chick and Roscoe (*Biochem. J.*, 20, 632, 1926) then found that the Vitamin A content of milk does depend on the ration and the Vitamin D content on the exposure to sunlight. A cow fed fresh grass in a dark stall gave milk low in D; she therefore manufactures D photosynthetically but does not manufacture A, which she merely passes on from the food intake. These findings had wide significance from the standpoint of milk production and the care of lactating animals. But what about human beings?

This question was answered by Dr. Alfred F. Hess in the January 1, 1927, issue of the *Journal* of the American Medical Association. The milk of a nursing mother was found to be incapable of curing rickets in rats. But after the woman had been irradiated with the ultra-violet mercury vapor lamp, her milk did very certainly cure rickets in rats. What was more interesting the pooled blood of these animals fed human milk after the irradiation showed more calcium than the pooled blood of the rachitic rats.

Dr. Hess placed the lamp at a distance of from thirty to sixty inches from the mother. She was irradiated every other day for a period of one month. The irradiations were at first carried on for but a few minutes; in the end they lasted nearly an hour daily. The conclusion of this work stated, among other things: "It is suggested that such irradiation be employed in order to protect infants from rickets and nursing women from excessive drain of calcium and phosphorus."

It is to be remembered that dried milk may also be endowed with high antirachitic and calcifying properties by ultra-violet irradiation, and that winter and summer dried milk, while differing naturally, have the same potential capacity for such endowment. (Supplee and Dow, *J. Biol. Chem.*, June, 1927, p. 617.)

These developments are really surprising when viewed coldly. They concern matters which would have been dismissed as half-mystic nonsense by the practical investigator just a few years ago. In fact, when these revelations were first made very many good research workers laughed at the ridiculous idea. While science must be on guard against ignorant credulity, it should not dismiss as obviously false or absurd statements which may, at first hearing, seem too highly speculative to merit serious consideration. Much that seems superficially contrary to reason is, in the last analysis, most reasonable of all.

It is easy to imagine the merry ridicule one would have met a few years ago by suggesting to some practical husbandryman that holding a lamp over a goat a few minutes every day would make it a very much better goat or to the practical physician that certain lamplight might act therapeutically on nursing women. Yet these are to-day known facts.

Faith is precisely the same quality in science as in mysticism or in pure speculation. But in the former case it is used efficiently and with discretion; in the latter two it is used profligately and without discretion. Even magic only errs by assuming implicitly what science seeks to demonstrate explicitly—that phenomena do follow laws which may usefully be correlated and heeded, but such an error is utterly devastating to scientific method. It is the highest art of the best investigators to preserve imagination and healthful credulity; while at the same time refusing to permit facile generalizations to leap madly ahead of established experimental data to questionable or totally false conclusions.

SOME STATISTICAL ASPECTS OF LIVINGNESS

By Professor D. FRASER-HARRIS

LONDON, ENGLAND

It was well said by Lord Kelvin that a subject does not really become a science until you have applied the method of measurement to it. Thus as regards electricity, so long as electricity consisted of rubbing a piece of amber and making it attract some bits of paper or of stroking a cat's fur "the wrong way" and getting sparks out of it, it was not a science.

But so soon as men were able to measure the intensity of a current and the quantity and "potential" of a charge, then the science of electricity had been born.

Now the science of biology, although it has made immense advances towards accuracy and definiteness in the last thirty years, suffers from this very drawback that as yet it has not been able to express its chief concern—life—in terms that are quantitative. You are alive; but how much alive are you? Is your heart more or less alive than a year ago? These are not foolish questions, although at present they may be unanswerable.

Clearly, a person about to die of a wasting illness is less alive than a healthy athlete just awakened from sleep. A person suffering from melancholia is certainly less alive than a prize-fighter about to enter the ring; but by *how much* less is, at the present moment, an extremely difficult thing to say. To measure the degree or intensity of livingness we must first agree upon standards or criteria. An example of how the problem has been solved in the case of vegetable organisms may help to make things clearer.

The dried seeds of a plant are presumably not dead, else when sown in the ground they would not grow up into plants as every one knows they do. But by merely looking at seeds, no one could tell whether they were alive or dead. A seed, having germinated, proves it *was* alive, but you have lost your seed though you have gained a plant.

In any packet of seeds by no means all are alive; but at the present time we have no simple method of pronouncing on their livingness, and certainly no simple method of telling how much any one seed is more alive than another.

The physiologist, the late Professor Waller, F.R.S., devised a method depending on the use of the galvanometer —an instrument in which the oscillations of mercury produced by the passage of electric currents can be photographed on a moving, sensitive surface.

It makes no difference whether these currents are produced by non-living, by vegetable or by animal matter.

Dr. Waller placed a seed of the scarlet runner (Phaseolus) in connection with a sensitive galvanometer, and stimulated the seed by passing through it the discharge from a Leyden jar. As a result of this, the seed made a "response" whose electrical counterpart was seen and measured in the galvanometer. The electromotive force of these momentary currents can be measured in fractions of a volt.

The following table gives the results at a glance, when seeds ranging from one to five years old were stimulated:

Years Old	Volts
1	0.0170
2	0.0050
3	0.0043
4	0.0036
5	0.0014

These investigations are particularly interesting both on account of their novelty and their exactitude. We can say, for instance, that the four-year-old seed was 4.72 times less alive than the seed one year old. Or we can state that the one-year-old seed was twelve times more living than the five-year-old. The great accuracy of this method is due to the fact that the measurement of the electromotive force of currents in the galvanometer is so precise.

When we come to animal organisms we have a problem which in the nature of things is much more complicated.

For, first of all, shall we try to measure the degree of livingness of the body as a whole or only of some organ or tissue within it?

Either method is theoretically possible.

There should be methods of determining the vitality of the entire animal; there must be more vitality in a healthy schoolboy than in an octogenarian—but *how much* more? The heat produced and lost by the body should be a useful criterion; and there is a method of estimating the heat-loss and expressing it in calories per unit of skin-surface per hour.

By this method it has been ascertained that the heat lost per square meter per hour by the adult male at rest and at a time about twelve hours from the last meal is forty calories, that by the female thirty-seven.

Physiologists have for long had reason to believe that the intensity of metabolism (that is, the totality of the chemical activities of living tissues) is rather more intense in the male than in the female; and now we have statistical evidence of this.

The case of the focussing power of the eye may suffice as an example of a statistical method applied to a single organ. We see a near object distinctly when its image is sharply focussed on the sensitive retina at the back of the eye; this image-formation is accomplished by the elastic crystalline lens becoming thicker at its center, a movement effected by the activity of a special circular muscle.

The older a person grows, the less elastic does the lens become and the feebler is this muscle of focussing. If then we make an estimate of the power of the lens and the muscle at any age, we can compare this with their powers at an earlier and at a later date. The refractive power of a lens may be stated in "diopters," one "diopter" being the power of a lens of one meter focal distance. By using this conventional standard, it has been ascertained that if we call the power of the lens at sixty years of age unity, then at ten years of age it is 14; at fifteen, 12; at twenty, 10; at thirty, 17; at forty, 4½, and at fifty, 2½. At seventy years of age the lens is only one quarter as powerful as it was at sixty.

In this way we have the statistical aspect of the decreasing vitality of the human crystalline lens.

Let us now turn to another tissue, the nerve, and view the statistical aspect of its activity. We shall employ as a criterion the speed of the propagation of the nerve-impulse in the nerves of different animals arranged in an ascending zoological series.

The notion underlying this is that the intensity of nervous vitality is less in a lowly than in a higher animal.

We do not for a moment mean to imply that because we call an animal "lowly" it is not as perfect as some other animal we call "higher." Each animal is perfectly adapted to its own surroundings, and each type performs perfectly its own particular functions. A snail is perfectly adapted to eat our young cabbages in a midsummer night, a frog is perfectly adapted to leap about the marshes and catch flies; but no one would maintain that the nervous system of a snail or a frog was to be considered

on the same functional plane as that of a human being.

Accordingly, we find the most striking quantitative differences between the various rates of propagation of nerve-impulses in animals arranged in an ascending scale. The rate is stated in meters per second:

Animal	Rate of Nerve Impulse, Meters per Second
Limulus, a crab (nerves of heart)	0.40
Limax, a slug	1.25
Cuttlefish	2.00
Limulus (nerves of body)	3.25
Hagfish	4.50
Lobster	12.00
Snake	14.00
Frog	28.00
Man	120.00

From these results we are permitted to say that the intensity of livingness in a human nerve is ten times that of the nerve of a lobster, thirty times that of a hagfish and sixty times that of a cuttlefish.

There is yet another line of quantitative investigation which can be followed out, namely, to estimate the amount of oxygen which a unit weight of a certain tissue absorbs or uses up in a known time. Evidently this is a very reliable measure of livingness, because, as is well known, the more active or alive a tissue is, the greater is the amount of oxygen which it utilizes. When it is dead it utilizes none.

The physiologists can estimate the amount of oxygen in the blood going to a muscle and also the oxygen in the blood coming from the muscle, the difference between these being the quantity of this gas retained by the muscle selected.

We state the results in cubic centimeters of oxygen per gram of the muscle per minute.

In the following table, a muscle in four different physiological conditions was investigated—fully active, gently active, in true physiological repose (that is, not contracting at all), and finally, after its nerves had been severed.

State of Muscle (cat)	Cc of Oxygen absorbed per Gram of Muscle per Minute
Fully active	0.08
Gently active	0.02
In true physiological rest	0.006
After nerves were cut	0.003

Here we have a quantitative chemical method which enables us to say that a muscle in full contraction is thirteen times as active as it is when at rest.

And further, we see that after a muscle has its nerve supply done away with, the vitality falls by one half of its resting value. By this chemical method it can be stated that a healthy, fully contracted muscle has twenty-six times the vitality of the same muscle after all its nerve influences have been abolished.

This same chemical method has been successfully applied to the study of the livingness of the heart of the cat. It was found that when that organ was beating normally, it utilized 0.014 cc of oxygen per gram per minute. When it was artificially stimulated to extreme activity, the figure rose to 0.08; but when, on the other hand, it had become slow and feeble, the figure sank to 0.007. It would therefore appear that the livingness of the heart beating normally is twice what it is when the heart is beating only slowly and feebly.

The living glands have been investigated in exactly the same way, as the following table shows:

Type of Gland	Cc of Oxygen utilized per Gram per minute
Pancreas (acting normally)	0.03
" (stimulated artificially)	0.10
Kidney (acting normally)	0.03
" (stimulated)	0.07
Liver (in inanition)	0.005
" (well nourished)	0.05

Thus it would seem possible that the pancreas (sweetbread) can be made to live three times as intensely as it normally does. The liver in a starving condition is ten times less alive than when thoroughly nourished. We have known for a long time that all depressing conditions, of which starvation is one, tend to diminish vitality, but it is only quite recently that we have obtained a statistical expression for that diminution.

A rather different line of research may be pursued.

The more sluggish a muscle or other organ is, the longer it can survive after the death of the animal of which it was a part. For it must be remembered that an animal can die as a whole (somatic death) and yet its various tissues, for instance, its muscles, can live for longer or shorter periods.

Thus, whereas the muscle of the human heart is alive two hours after bodily death, the body-muscles are alive five to six hours thereafter. And whereas the muscles of a rabbit will live for eight and a half hours after the death of the animal, those of a sheep will survive for ten and a half, those of a dog for eleven and three quarters, those of the cat twelve and a half and those of the frog for from twenty-four to forty hours.

This is an interesting statistical aspect of vitality.

There is still another method open to us, at least as regards a muscle, namely, to calculate the time occupied by the muscle in performing a single act of shortening or the twitch. If we compare two types, the one of extreme sluggishness such as the muscle of a tortoise, and the other of extreme activity, such as the wing-muscle of a wasp, we shall find that, whereas the former takes 1.8 seconds to perform a single shortening, the latter takes only 0.009 of a second. In other words, the wasp's muscle "works" two hundred times as rapidly as the tortoise's.

The notion of speed in connection with life is by no means unfamiliar. The common expressions, to live "a fast life" or to find a place "very slow," are not entirely without scientific sanction.

Nature dislikes speed beyond a certain rate and happenings that are too sudden. The nervous system in particular is intolerant, for instance, of loud noises occurring near us with extreme suddenness.

Nature has set limits to the speed of action, to the intensity of livingness. To take a specific case; she has so arranged things that the heart is enabled to go on beating, as we say, "forever," just because it actually rests for a longer period, fourteen hours out of the twenty-four than it works, ten hours.

"It's the pace that kills" is a more appropriate phrase than "burning the candle at both ends." For, though burning the candle at both ends may describe doing without sleep and so depleting the reserves of vital resources, yet the expression, "It's the pace that kills" is a closer description of the anti-vital effects of a "fast" life.

The heat of a fire depends, for one thing, on the *rate* of the draught through it, so too the intensity of livingness depends on the rate at which the chemical and oxidative charges go on in the living substance. These latter can be accurately measured in terms either of the oxygen absorbed or of the carbon dioxide excreted.

When the blacksmith wants a very hot fire, he uses the bellows vigorously for a short time; and when livingness is to be expressed at its maximum of intensity,[1] the tissues receive and dispose of the life-supporting oxygen up to the limit of their respiratory capacity.

[1] Or potential, to borrow a phrase from the electricians.

The diminution of vitality in a melancholic invalid has its counterpart in the fire that smoulders after the blacksmith has closed down the forge.

This absorption of oxygen is directly proportional to the muscular activity of the animal.

A horse at rest, walking and trotting absorbs per minute 1.6, 4.7 and 8 liters of oxygen, respectively. Therefore, the intensity of its muscular activity is five times greater when trotting than when at rest.

There is nothing new or strange behind this; we often hear it said of some one towards the end of a wasting illness —"he has not much vitality left"; but it is only quite recently that we have contrived to give that "much" or that "little" a quantitative or statistical value.

One is reminded of the man who lost his portmanteau as he was embarking on a Channel steamer; his fellow-travellers crowded round and expressed "*much* sympathy." A Quaker, who had witnessed the accident, stepped forward and said; "I am sorry for you to this extent," and handed him a packet of banknotes.

THE UNFIT SURVIVE

By Dr. HERBERT MAYNARD DIAMOND

NEW YORK UNIVERSITY

Economic Obscurantism

We are not required to theorize very much about the matter of getting a living. We may sit back in our armchairs and speculate as to the influence of the moving pictures upon the morals of young girls and conclude that it is good, bad or indifferent—largely, I imagine, taking the last picture we may have happened to witness as a basis for judgment. Such speculation can not do much harm and is not likely to accomplish much for good; after all, we shall never know just what is the influence of the cinema upon the morals of young girls. On the contrary, however, the farmer does not speculate about the result of using a new fertilizer upon his soil. He puts it to the test and can measure the difference with and without almost to a quarter peck.

Methods and devices utilized in the direct task of getting a living are always capable of similar immediate test; they obtain results, or they do not; schemes and artifices to meet economic ends either succeed or fail. There is a cause and effect relationship here which is rarely obscure. Yet primitive man managed to make the matter of living well very complex, for into it he introduced the element of illusion—of belief in spirits and spiritual agency. His interpretation of life resulted in the incorporation of his religion into his economic outfit. Embracing this additional factor the simple business of getting a living became complicated in manifold ways. Practical observations of results which contact with nature daily afforded him became confused with an unlimited number of theories and notions upon the consequences of spiritual agency. The elements of illusion, of belief in the imaginary environment took, as it were, a place side by side with the realities.

The demands made upon primitive men by the spirit host involved inroads upon their time, energies and resources which, if they had examined the facts solely in the light of immediate material expediency, were plainly of harmful consequence. But believing they were subject to the control of forces which we think to be non-existent they frankly acted upon that premise. The interjection of the philosophy of animism into their interpretation of life experience necessarily modified and complicated savage reactions to economic needs. Our purpose is to ascertain one aspect of the consequences of this additional factor in the economic life of the groups among which it prevailed.

The Basis of Wealth

All men must work to live; for there is a lack of balance between human needs and available resources; nature of her own efforts does not supply us gratuitously with all the things we need or want. To make up this natural shortage we must apply ourselves to our environment in order to force it to yield more than that which, without our toil, it would freely yield to our use. The effort to live when thus engaged in by human beings becomes what is generically termed industry; food, clothing and shelter and all manner of goods must be provided. The economist calls these goods required for the satisfaction of wants wealth; and to obtain wealth in-

dustry is required. Hence, some expenditure of energy is a necessary condition of life for any group of human beings, although such expenditure will vary in intensity as between different groups, owing to environmental variations. The native of the luxuriant tropic may need to make no greater effort for a food supply than to pick and to prepare for eating the fruits of his jungle forest; the Eskimo, at the other extreme, must ceaselessly engage in the toilsome and hazardous chase of the scanty wild life of the ice fields. Yet each in his own way must work.

Among human beings the effort to live is characteristically something more than an effort merely to maintain life. Men try, as the animals do not, not only to live but to live well. Living well, as a formula, has meant accomplishment in two diverse economic directions, namely, more enjoyments and less work. Mankind has always strived to devise means and artifices by which labor might be less arduous; and to improve the quantity and quality of those goods the environment affords.

At base in social evolution,—progress in man's realization of his interests, has been constant advance along economic lines. An economic surplus great enough to release some individuals from the direct toil of material efforts is required to permit the rise and development of literature, art, music and the drama. The clue to the cultural development of a society therefore is likely, if not certainly, to be found in its economic organization. When we study the bearing of the religious beliefs and practices of early men, as it affects their economic welfare, we are hitting at a vital point for this reason; particularly if we may demonstrate that superstition did actually participate in the operation of the more-goods-less-work formula.

The Economic Environment

Men's industry is frequently required in the production of benefits which may not be measured by the yard or ton. Before the pioneer could raise his corn, he first set out to clear the forest. Just so, it has been the practice frequently of late years to employ men to float a thin film of oil upon the stagnant marsh waters adjacent to some of the large cities in order to prevent the larvae of the mosquito from developing. Indirectly, the purpose is to prevent the spread of contagious diseases through the medium of the mosquito in these centers of population. Similarly, by preventing the mosquito from breeding yellow fever has been eliminated from former plague-ridden communities; malaria likewise has been brought under control. Although no addition to immediate goods is yielded by these efforts, the results are of inestimable value. Men's labor often, in this wise, works to bring about results, immaterial but calculated nevertheless to make the situation more favorable for the prosecution of their general interests. In this vein we may consider its influence upon primitive industrial and living conditions.

Taboo on Animals

The taboo of the savage is a spiritual *noli tangere*—a prohibition enforced by the belief that to molest the protected object, animal or persons will result in summary vengeance by an enraged spirit. The taboo takes origin in the notion that the thing tabooed is vested with the interest if not the embodiment of some one of the spirit host. Primitive men viewed that many living creatures either were the resident of some spirit, or that such creatures themselves were essentially supernatural, or that they came under the care and protection of some outside deity or devil. In any case,

such creatures were unmolested, decidedly so, from the conviction that the offender by his sacrilege might bring not only upon himself but upon his entire community the wrath of a vengeful demon. How such beliefs were arrived at is largely a matter of speculation; the results of them, however, are not. For it is obvious that so far as these taboos worked out practically, the consequence is direct interference with the operation of the processes of natural selection.

From everything we know of the experience of the human race, it is safe to state that, with the exception of certain insects,[1] and microorganisms, man has proved himself the dominant organism of nature. In the event that men find other creatures either dangerous, destructive or simply noxious and annoying, they may almost without exception clear their immediate environment of such pests and may live in comparative immunity from them. We have not, of course, entirely wiped out such species, but we have driven them to remote places far from the village and the city. When, however, superstition protects the lower organisms men are restrained from behaving naturally toward them and from exerting an altogether natural effort toward the elimination of undesirable and unwelcome neighbors.

Snakes

Outstanding among such superstitions is the one which protects snakes; early men of many tribes regarded the snake as a creature endowed with particularly supernatural qualities. "The Sea Dyaks would not intentionally kill a cobra for this reason."[2] In India, very remarkable is the effect of such veneration, especially that regarding the cobra. "No orthodox Hindu will ever kill serpents even if bitten, for it is believed that any injury done to them would bring on leprosy, sterility or ophthalmia."[3] "The cobra being an object of worship, it is a deadly sin to kill it."[4] "Though the snakes in this country are noxious to the natives, yet the ancient veneration for them is still maintained. No one dares to injure them or to drive them away by violence; and so audacious do they become that they will sometimes creep between peoples' legs when they are eating and attack their bowls of rice, in which case retreat is necessary until the monsters have satiated themselves and taken their departure."[5] It is related that a certain village in Northern India was not so long ago suddenly deserted by all its inhabitants. No persuasions would induce the people to return, and on inquiry it was found that the panic among the villagers was caused by an unexpected visitation of snakes who had established themselves comfortably in the precincts of the village.[6] In fact, so prevalent is the cobra that it is figured to kill about twenty-five thousand people annually in that country;[7] and in 1904, official records said that sixteen thousand head of cattle were destroyed by this creature.[8]

The veneration and consequent protection to snakes also is found among African groups. The Wakerewe of the Victoria Nyanza region do not kill the gigantic snakes that frequently occur or the other kinds, but look on calmly when these reptiles visit their huts and con-

[1] The tsetse fly is one of the outstanding cases of exception; there are also other species, as the boll-weevil, which have baffled the efforts of the entomologists to control.

[2] Roth, "Natives of Sarawak and British North Borneo," I, 390.

[3] Thurston, "Ethnographic Notes in Southern India," 285.

[4] *Idem*, "Omens and Superstitions of Southern India," 124.

[5] Thurston, *op. cit.*, 89.

[6] Monier-Williams, "Brahmanism and Hinduism," 325.

[7] *Ibid.*, 319.

[8] Gregory, Keller and Bishop, "Physical and Commercial Geography," 143.

sider those to be fortunate who are killed by the bite of a poisonous snake.[9] The Kaffirs fear to kill a boa constrictor, and he who happens to do so is forced to spend his waking hours for several weeks lying in a stream of running water to purge himself from his sinful act.[10] And among the Ewe peoples in former times he who killed a python was burned alive for committing so heinous a sacrilege.

In America also traces of this ancient superstition are to be found. The Dakotas would not kill a snake;[11] and but few Cherokee would kill a rattlesnake; if they do kill it, they must undergo ceremonies of purification,[12] having exposed themselves to the contagion of spirit wrath—they must undergo prophylaxis. It is safe to conclude that with them also religious sanction was extended to the snake.

The Crocodile

Further evidence of the animal taboo is to be found respecting the crocodile. Crooke in speaking of the veneration for this creature in India remarks, "It is a general rule among savages to spare crocodiles, or rather only to kill them in obedience to the law of blood feud, that is, as a retaliation for the slaughter of men by crocodiles."[13] It has been noted in New Georgia, where the crocodile is taboo, that in the eastern district they may be killed but not eaten; clearly a survival of their one-time immunity. At Rubiana, however, they may not even be touched but "A man of that district whose child had been carried off by a crocodile had the *hopi* (taboo) removed from these creatures, as far as he was concerned, until he had killed a hundred,"[14] evidently in accordance with the law of blood revenge.

The Dyaks afford another illustration of Mr. Crooke's point. For they will not kill crocodiles except in blood revenge.[15] "From superstitious motives, the Dyaks do not interfere with the crocodile until it has developed a man-eating propensity. Then they turn out in a body and make war upon the race and slaughter it wholesale."[16] At the present time, the ancient custom survives in merely symbolic form.[17] On the Lower Niger snakes are "fed and tolerated to such an extent that in those towns in which they are sacred, although they become a pest and even a danger to the people, they are all the more pampered and spoilt."[18] In the town of Brass, the pythons were tended and fed with zealous care by their own especially appointed priests and were never molested or interfered with.[19] As these pythons feed principally on fowls and goats, "it is quite a common event of a morning to find in one hut as many as four or five or even more pythons lying in a semi-comatose condition after having swallowed some of the live stock which they had found on the premises. Unwelcome as the sacred visitors are held on this account, so strict are the rules, so severe are the penalties regarding them that they are left unmolested."[20]

At Bonny, finally, the natives decided to slaughter the iguana "on solid common-sense grounds, for had not the iguana been their mortal enemy for years, by eating their fowls and chickens before their very eyes, thus destroying

9 Kollmann, "Victoria Nyanza," 135–136.

10 Frazer, "Golden Bough, Taboo," 221–222.

11 Spencer, D. S. 4A; 35.

12 Mooney, "Myths of the Cherokee," *B. A. E.*, 19, I, 294.

13 "Folklore of Northern India," II, 282.

14 Summerville, "Ethnography of New Georgia," *J. A. I.*, 26, 386.

15 Hose and MacDougall, "Men and Animals in Sarowak," *J. A. I.*, 31, 190.

16 Roth, Nat. "Sarawak," I, 446.

17 *Ibid.*, 222.

18 Leonard, "Lower Niger and Its Tribes," 328.

19 *Ibid.*, 219.

20 *Ibid.*, 329.

about the only means a woman of the lower class or one who had ceased to please her lord and master had of making a little pin money."[21] Very likely it was contact with civilized men which hastened this decision. The natives fully recognized the toll of the taboo. Superstition is not a gratuitous folly. Early men well knew that their immediate interests were hurt; they thought it better policy, however, to bear the loss. Perelaer speaks of this fact also and remarks that with this one exception crocodiles in Dyak land are very much honored and are offered many kinds of sacrifice—hogs, chickens and the like. Such practices, it is said, have hindered the efforts of the Netherland government to root out the species.[22,23]

In Madagascar "the crocodile swims in every river and lake, and from dread of its power the natives will never kill one except in retaliation for one of their friends or neighbors who has been destroyed by a crocodile. They believe that the wanton destruction of one of these reptiles will be followed by the loss of human life in accordance with the principles of lex talionis."[24] And in Africa, on the Island of Damba in Lake Victoria Nyanza, crocodiles may not be molested and here they become very dangerous to the natives in going upon the water.[25]

Upon this formidable saurian the taboo against killing does not seem to have been so strict as that against the destruction of snakes; nevertheless comparative immunity was afforded it thereby. It was permitted to live and breed near the homes and haunts of men, and by the Dyaks was even pampered and fed. Human life was thus constantly endangered, and travel upon streams and near their banks made precarious.

The Felines

The great felines, the tiger, the leopard and the lion, were similarly venerated by many primitive peoples. In North India, the tiger is held sacred by the Kisans and the Santals, who never kill such an animal. They believe that in return for such devotion the tiger will spare them.[26] In Africa native behavior indicates this taboo to have been a feature of the customs of past times. Among the Ewe a man who kills a leopard is theoretically put to death; but really the culprit escapes by paying a fine and by performing propitiatory ceremonies. Among them no leopard skin may be exposed to public view.[27] The Kaffirs and the Hottentots both seem to regard the killing of a lion as morally unclean and isolate and purify the lion-killer.[28] The natives of the Loango Coast after killing a leopard hold a public ceremony in which they publicly apologize to him for having been so rude as to kill him.[29] Clearly we may see in this the carrying over of past actuality into a present formality. The group discontinuing a former practice retains the form but abandons the substance.

In Livingstone's account of the territory through which he traveled, the original situation still obtained; he said, "There are also a great many lions and hyenas and there is no check on the former, for the people believing that the souls of their chiefs enter into them never attempt to kill them."[30] At one

[21] DeCardi (in Kingsley's W. Afr. St.), 314.

[22] Perelaer, "Ethnographische Beschrijving der Dajaks," 7.

[23] Perhan, "Sea Dyak Religion," *J. R. A. S. St. Br.*, 14.

[24] Sibree, "Great African Island," 269.

[25] Roscoe, "The Baganda," *J. A. I.*, 32, 6.

[26] Crooke, "Folklore of Northern India," II, 218.

[27] Ellis, "Ewe Speaking Peoples," 74.

[28] Frazer, "Golden Bough, Taboo," 220.

[29] Bastian, "Die Deutsche Expedition an der Loango-Kuste," I, 243.

[30] Spencer, "Principles of Sociology," I, 330.

time therefore there unquestionably existed in Africa a widespread taboo affording protection from molestation to these dangerous and destructive animals.

However, so far as Africa is concerned, we must base our judgment almost entirely upon illustration from social survival, that is to say, the preservation in present social practice of ancient customs in form rather than in actuality. This is of course a commonplace element in social evolution. We see it in the chocolate Easter egg. There is, however, in the case of felines a tendency in the direction of modification of socially disadvantageous practices. Such changes came but slowly in the passage of time, gradually passing the original expensive and harmful custom into one of formality and safety. The earlier demand of superstition is met by a form rather than by a fact.

Birds

Religious protection extends similarly to the feathered creatures. The Kenyahs of Sarowak will not kill a hawk. The writer tells us, however, that "they would not prevent us from shooting one if it stole their chickens."[31] They were aware of the cost of the taboo on the hawk, but they dared not themselves to kill it. The Mongols permit crows to perch on top of loaded camels and to steal mutton before their very eyes. Hawks swoop down in the market place at Urga and snatch eatables from the hands of the unwary.[32] Among some South African tribes "the eagle is sacred and is never killed . . . though it carries away large numbers of domestic chickens and often kills young lambs and kids."[33] In Coomassi the Tshi allow vultures to fly in hundreds untouched, and they are so bold as to pounce upon fish or meat carried on the head.[34] Even a taboo on birds may be fraught with distinct disadvantages.

Other Creatures

Among the Dusuns the rats destroy the crops but are not molested.[35] The rat in North India is also very sacred and may not be killed and becomes a great household pest.[36] In the light of our present knowledge of the rat as a disease-carrier, we may appreciate the potential menace of this superstition to human interests.

The bear is an object of like veneration; in North India some groups refuse to kill it. The Crow Indians of America would neither hunt nor trap a bear; they believe it bad luck and will not touch the food.[37] In this case the result is to refuse a source of food supply.

In Burma even hardened convicts will not harm the vermin that infest their mattresses. Shway Yoe remarks, "A story is told of a man who allowed the snake who killed his father to wriggle away unmolested"; and he continues, "I myself have seen a Burmese mother take up between two bits of bamboo the scorpion that had stung her little son, and simply throw the hideous creature out of the window."[38] Such actions are dictated by the Buddhist injunction against killing.

Monkeys are a source of great annoyance and are protected in the same way from human interference. In Sarowak the *dok* (macacus nemestrinus) or the

[31] Hose and MacDougall, *op. cit.*, *J. A. I.*, 31, 178–179.

[32] Gilmour, "Among the Mongols," 235.

[33] MacDonald, "South African Tribes," *J. A. I.*, 20; 115.

[34] Ellis, A. B., "Tshi Speaking Peoples," 213–214.

[35] Roth, H. L., "Nat. Sarawak," I, 403.

[36] Crooke, "Folklore of Northern India," II, 241–2.

[37] Jenks, "Faith in the Economic Life of the Amerind," *Am. Anth. N. S.*, 2; 681.

[38] Shway Yoe, "The Burman," II, 40.

cocoanut monkey is very common and they will kill it only when stealing their crops. "The *dok* does not help them in any way but only spoils their crops."[39] Here, again, a grain of common sense tempers the taboo. The religious injunction is not sufficiently binding to protect the malefactor if caught in the act. In parts of India likewise the monkey is sacred; "often a troop will make its appearance in an Indian village, tear off the roof of a native house and do even worse damage out of sheer wantonness, yet no householder would ever dream of reprisals. The sacred character of the monkey shields him from all harm."[40]

The unfit survive. Men die that snakes may live—an outrageous inversion of the operation of natural selection. Man's unique privilege of rationalization brought him to the belief in spirits; the belief in spirits, in turn, led him to endow creatures, far below him in the evolutive scale, with powers far above his own—as he viewed the matter—in the spiritual scale. Forbidden, then, to exercise his natural advantages in warring on his enemies, idly he sat by viewing the toll of death and destruction with complacent faith,—his spirits had so decreed.

When we consider the fact that this condition obtained among men of the lowest culture we may the more accurately estimate the monstrous cost. Such men, at best, had but a tenuous grip on life; their knowledge of the industrial arts was rudimentary, their resources meager and uncertain. Indeed, so heavy was the burden of maintaining life that among themselves natural selection operated inevitably and ruthlessly. The old, the crippled and the blind, because they could not fend for themselves, slowly died for want of care, were killed outright by compassionate relatives or were abandoned; the productive had no surplus to share with the non-productive. Yet the tiger, the crocodile and the rat lived, and, if need be, at the expense of an always impoverished humanity. Had these men regarded their noxious neighbors solely as physical in attribute, conquest would have been quick and decisive; regarding them, however, as supernatural in endowment, the war decreed by the dictates of nature was delayed at behest of imaginary powers. To what extent human progress was delayed by the perversion we can not state; it suffices, however, to note the retarding pressure of this cult.

[39] Hose and MacDougall, *op. cit.*, *J. A. I.*, 31, 191.

[40] Monier-Williams, *op. cit.*, 222.

SCIENCE AND RELIGION

By Professor I. W. HOWERTH

STATE TEACHERS COLLEGE, GREELEY, COLORADO

To insure the rapid extension of man's reign over his empire, science and religion must somehow be brought to terms. An unfriendly relationship between these factors of social change means necessarily something less than the maximum of effort and achievement in promoting the well-being of mankind. There is nothing at present more desirable than the cooperation of science and religion in the promotion of human progress. I purpose, then, to discuss some of the proposed methods of reconciling science and religion, and to point out and elucidate a mode of reconciliation that would call for no diminution of the enthusiasm and efficiency of either. First, let us consider the differences existing between science and religion, if any, with regard to the nature of truth, its value and the methods of its discovery.

TRUTH AND ITS DISCOVERY

Truth is commonly defined as a harmony, agreement or correspondence between our thought and reality; that is, between our thinking and the things we think about. Both science and religion accept this view of truth. They agree, too, in the conviction that a knowledge of the truth is valuable. Knowledge, it is said, is power; and power is in itself something to be desired. It is a plain fact that man's power of achievement has advanced with the advancement of his knowledge. So, too, it is recognized everywhere, and by all who have given the matter a moment's thought, that truth and knowledge are valuable as a guide to action. Blind action may be effective, but in changing conditions it is not as likely to be so as action that is intelligently directed. And, finally, both science and religion are equally convinced that the truth is valuable as a promoter of intellectual freedom, and such freedom, at least in the abstract, is regarded as something to be desired.

Both science and religion, then, profess unqualified respect for the truth. Both regard it as socially serviceable, and quote with equal approval the saying of Jesus, "Ye shall know the truth, and the truth shall make you free." So far, then, there is no conflict between science and religion, if both are sincere in what they profess. Disharmony between them arises, however, in regard to the most reliable source of truth, and the best method of finding it out. There have been, and are, various ideas on this important point. Some of these we shall now consider.

We need hardly be detained by the all too prevalent conception that truth, at least particular truths, may be ascertained by various forms of hocus-pocus. Primitive man reposed great confidence in magic, in the divination of truth by observing the flight of birds or investigating the condition of their entrails; in oracular pronouncements of supposedly inspired persons; in dreams, signs, etc. Unfortunately, there are many now, even among those supposed to be educated, who expect to find truth in similar fashion—star-gazing, fortune-telling, card-shuffling, the ouija board, the chance arrangement of coffee grounds, and the like. All such "vestigial remains" of primitive beliefs should have no place either in science or religion. We turn to methods more deserving of attention.

It is sometimes said that truth is

intuitively perceived, intuition being regarded as independent of the reasoning process. It is probably the fundamental element in that process. Anyhow, it is safe to say that the science of psychology does not regard intuition as outside the field of natural psychic phenomena, and will explain it, or attempt to explain it, as a natural result of individual or of racial experience, or of both. Moreover, no psychologist would contend that what we call intuition is always safely reliable, or that it serves as a guide, except within very narrow limits. It is not likely, then, that intuition will ever be regarded by the most careful seekers after truth as an effective and reliable means of obtaining it. Science and religion are not divided on this ground.

Again, there are those, particularly in oriental countries, who argue that truth is to be gained by a method quite as economical of effort as is the method of intuition, namely, by passive reflection, by meditation; in short, by assuming a certain attitude. Truth, they hold, is an emanation from the divine mind. The mind of man, being in reality a part of the divine mind, may receive truth as an influx, providing he puts himself in a properly receptive attitude. The attitude to be preferred is apparently one of perfect mental passivity. It is sometimes called putting oneself "in tune with the Infinite." The most effective procedure, they say, is to "retire to the silence," and restrain as nearly as possible all mental activity. Truth will then steal into the mind. Emerson, who was himself something of an oriental, gave currency to this view by his doctrine of the oversoul. According to his teaching, the minds of men are but the organs of a mysterious entity called the oversoul. Or they are the harps which, when properly attuned to the divine mind, give off a music apparently their own, though the vibrations are produced, so to speak, by a breeze from the Infinite. At any rate, truth is an influx of the divine mind, and may be had by any one who reverently listens. It was so the prophets glimpsed the truth.

> The word unto the prophet spoken
> Was writ on tables yet unbroken;
> The word by seers and sybils told
> In groves of oak or fanes of gold,
> Still floats upon the morning wind,
> Still whispers to the willing mind.[1]

Since the mind appears to be always active, even in sleep, complete mental passivity is a condition difficult, if not impossible, to attain. Ideas do come and go in a manner which psychology does not as yet profess to explain, but there can be no question that some of these ideas that so mysteriously enter the mind are anything but truth. For this reason it must always be necessary to subject ideas flowing into the mind to a critical examination in order to determine their validity and to estimate their value. At any rate, science and religion are never likely to get together on the ground that truth enters when the gates of the mind are properly opened, or that it surrounds the mind as the atmosphere the body, and is to be taken in by a process involving a less expenditure of energy than does the act of breathing. Mental activity, rather than passivity, is the safer prescription for successful approach to the truth.

While it may well be admitted that meditation and reflection should be practiced, particularly in the western world, much more than they are, they can not be regarded as an exclusive or superior method of truth-seeking, or as giving validity to the doctrine that truth and knowledge have their source in the divine mind and are diffused by a process similar to radio transmission.

Science and Revelation

We come now to a view of truth and a method of ascertaining it, concerning which science and religion are definitely, and perhaps irreconcilably, at war. It

[1] Emerson, R. W., "The Problem," Complete Works, Concord Edition, Vol. 9, p. 8.

is the view or idea that Omniscience, the possessor of all truth, has once for all revealed to mankind all we need to know, through chosen representatives who were specially inspired. The idea of inspiration is, of course, as old as the belief in disembodied spirits. It was held by primitive men as one of the fundamental ideas of their philosophy. In primitive times, however, good and bad spirits alike were supposed to speak by inspiration. But the belief now entertained by religion almost the world over is that God, himself, has employed inspiration to reveal the truth to man, which truth is embodied in sacred documents—"sacred books," as they are called, such as the Rigveda of the Hindoos, the Zend-Avesta of the Zoroastrians, the Koran of the Mahommedans, etc., and the Bible of Christian nations. Each of these books, it is maintained by their respective "defenders," "is given by inspiration of God, and is profitable for doctrine, for reproof, for instruction in righteousness." The followers of each religion often go so far as to maintain that their own sacred book contains all truth; that other books, and of course scientific inquiry, are unnecessary. The Caliph Omar is reputed to have said of the seven hundred thousand manuscripts in the Alexandrian Library, "If they agree with the Koran, they are useless; if they disagree, they should be destroyed." And St. Augustine laid down the law concerning our Bible which many apparently accept to-day: "Nothing is to be accepted save on the authority of Scripture, since greater is that authority than all the powers of the human mind."

But, without denying great value to the so-called sacred books of the world, there is an increasing number of people who are coming to believe that their value lies not in their mysterious inspiration but in the fact that they are records of the evolution of man's conceptions—particularly his religious conceptions, beliefs and aspirations. This is the view that science accepts. It was well expressed by Andrew D. White, who said: "The inestimable value of the great sacred books of the world is found in their revelation of the steady striving of our race after higher conceptions, beliefs, and aspirations, both in morals and religion. Unfolding and exhibiting this long-continued effort, each of the great sacred books of the world is precious, and all, in the highest sense, are true. Not one of them, indeed, conforms to the measure of what mankind has now reached in historical and scientific truth; to make a claim to such conformity is folly, for it simply exposes those who make it and the books for which it is made to loss of their just influence."[3] Thus, while these books may still be regarded as revelations, as science itself is a revelation, "revelation" in the earlier sense is no longer applicable. Indeed, it would perhaps be better not to employ the word at all, for most people have the old idea, and are thus brought in conflict with the scientist who finds in the doctrine of inspiration one of the chief enemies of his disposition to inquire and to explore.

Of course, the idea of revelation, as usually entertained, has been given up, wholly or in part, by many who regard themselves as religious. It is certainly not held by some of the more advanced thinkers of the church, and as a rule it is not admitted by those who cultivate science. Still it is prevalent throughout Christendom. Indeed, it is hardly too much to say that science and religion, on this doctrine of a divine revelation, as ordinarily conceived, are diametrically opposed. The very beginning of scientific thought and activity, prompted by doubt and curiosity, implied a disbelief in revelation, and the growth of science has certainly been away from the idea. Indeed, it must flatly reject it, since it is plainly derived from the primitive man's very natural but erroneous belief in pos-

[3] White, A. D., "A History of the Warfare of Science with Theology in Christendom," Volume 1, p. 23.

session. In so far, then, as religion clings to the doctrine of revelation, there would seem to be no reconciliation between it and science. This entire idea, however, may best be considered by a frank discussion of the relation of science and the Bible.

Science and the Bible

As everybody knows, the Bible was long regarded, and is now regarded by millions of people, as the exact and infallible Word of God. They suppose it to have been transmitted through its reputed authors, and, according to many, without error in its transmission. It is the view of the "fundamentalist," as I understand it, that it is divinely inspired in its minutest particulars. No wonder, then, that it is regarded by him not merely as *an* infallible source of truth but *the* infallible source of all truth, or at least of all truth that it is necessary for man to know. It is a consistent view. If it is the "Word of God," the very words of his mouth, it must be strictly true, since it is "impossible for God to lie," or, if omniscient, to be mistaken. Every statement in it, then, must be literally, historically and scientifically correct. From it may be constructed, not only a history of the world, but a cosmology, a geography, a biology, an anthropology, etc. True science, then, must be derived from a study of the Bible, anything else pretending to be scientific is "science falsely so-called." Clearly, if this is the case, the investigations of the scientist are unnecessary or they are impious.

This being the view, long entertained by the church, we can easily understand why, in the early history of science, there was so bitter a conflict between science and religion. The pursuit of scientific knowledge was opposed to the fundamental idea of the church, and the church could not fail to recognize it. It undertook, therefore, to destroy science, and failed. Science has destroyed one by one the survivals of primitive thought in religion, but has thus far failed to eliminate the survival contained in the idea of a Divine revelation. Have we here, then, the ground of a perpetual conflict between science and religion? Or, can it be removed?

As already said, there are many, both in religion and in science, who have solved the difficulty in a manner satisfactory to their own minds. They believe themselves able to "reconcile" the Bible and science, or they have accepted the view that religion is not concerned with scientific truth, or *vice versa*. But it is a plain fact that millions still adhere strictly to the idea that the Bible is an infallible source of truth, even in the particular field that science claims as its own, that is, the field of the so-called natural sciences. It should also be plain that this idea is indefensible, and is doomed to obsolescence and final disappearance.

Obsolescence, I say, for ideas do not die suddenly and disappear at a given moment; they are supplanted or transformed. Many who have frankly surrendered the extreme idea of biblical inspiration still entertain an elastic conception of it; inspiration "with limited liability," as some one has said. The Bible is inspired, they say, it is truly the Word of God, but it is couched in such language and employs such images as the minds of the people of the time in which it was written could understand. Why it should have been adapted to the understanding of men in an earlier stage of civilization, and to the mystification of the men of to-day, it is difficult to comprehend. But anyhow, the Bible, they say, is true, and in so far as science is true there can be no conflict. Anything that appears to them to conflict with the divine truth of the Bible will be regarded as irreconcilable, and so there will be perpetual cause of conflict. Since it is easier to deny than to reexamine, there must be constant demands for adjustment, and always disputation in regard to who should make it. Unless

the truths of science are apparently in harmony with biblical texts as commonly interpreted, the former will always be regarded, as I have said, as "science falsely so-called." From the beginning of science, the usual procedure has been: first, a proclaimed discovery of scientific truth, then a flat denial on the part of religion; the truth involved is plainly in conflict with the Bible, and there is a great flourish of texts to prove it. Failure so to do is at length followed by the declaration that the Bible teaches it, and thus a compromise is effected by far-fetched reconciliations of textual statements with ascertained facts.

Now it looks, to an impartial observer of the existing situation, that any attempt to reconcile science and the Bible in the field of the natural sciences is futile, a mere waste of energy. There is no such reconciliation.

As an example illustrative of the futility of spending time and thought in an effort to reconcile science and the Bible, let us glance at the first chapter of Genesis. Let us read a portion of that chapter, interjecting here and there such comments as we might reasonably expect a reader fairly well informed in science to make who was reading that chapter for the first time, and who had been told that it is a scientific account of creation.

> In the beginning [a beginning is inconceivable] God created [out of nothing?] the Heaven [that "undiscovered country"] and the Earth. And the Earth was without form [impossible] and void [void of what?]: and darkness was upon the face of the deep [How could there be a "deep," if the earth was without form and void?]. . . . And God said, "Let there be light [Light without a sun!]; . . . and God divided the light from the darkness [evidently they are supposed to be material things!]. . . . And the evening and the morning were the first day [and as yet no sun!]. And God said, Let there be a firmament in the midst of the waters [evidently the firmament, that is, the sky, is supposed to be a material thing!].

And so on. How much credence would such a reader give to the chapter as "a scientific document"? Evidently none at all. Let him read it as a poetical conception of an early writer, and the effect would be different.

Is it not clear, then, that it would hardly occur to an impartial reader, either to accept the first chapters of Genesis as a scientific account of creation, or to suppose it possible to reconcile the account there given with the findings of modern science? So with the Bible as a whole, science can not accept its crude and naïve explanations of natural events, as a literal account of the facts. Science knows that all these biblical stories are derived from conceptions long antedating the appearance of the Bible, many of them, in the main, identical with stories found in the mythology of heathen nations. The Bible, therefore, whatever else it may be, never can be regarded by science as an infallible source of the truths that men are seeking in the field of nature, and many of the most religious men of to-day concede that science is right.

But there are even scientists who, perhaps because their interest does not extend beyond the study of material things, or because they are over-zealous for peace, are willing to concede the claim of many theologians who have themselves given up the infallibility of the Bible with respect to natural science, that the Bible is an infallible source of truth with respect to religion and morality; it is "an infallible guide to faith and practice," they say, to quote the usual form of expression. But as science extends itself into the field of morals, as it is now doing and will do more and more, this claim too will be rejected. The evolution of morals is as plain to the student of the evolution of society as is the evolution of the material world; and morality, which necessarily involves conduct, needs the assistance of science in its direction, as does any other form of activity. We need and must have a scientific ethics. Science is bound to extend its area to include the study of all social phenomena; it is bound to lay claim to the entire field of phenomena,

the phenomena of mind and morals, conduct and religion, as well as the so-called phenomena of nature—to spiritual phenomena as well as material phenomena. In a word, science claims, or should claim, for its subject-matter the entire realm of the knowable; and the admission of infallibility with respect to knowledge in the field of morals, or of infallibility, anywhere or at any time or upon any subject, is fatal to the full development of science and its potential social beneficence.

Is this to be regarded as a rejection of the Bible? Many will think so. They will regard the admission that the ancient literature contained in the Bible has no more claim to infallibility than any other ancient literature as what they call its "rejection." It is rather to be considered as a rejection of certain ideas concerning the Bible. Science no more "rejects" the Bible than it does any other piece or collection of literature. Rejection is not the word for it; the word is used, one feels, because to many minds it carries a suggestion of moral deflection. It is more impressive and condemnatory to say of science that it rejects the Bible than it is to say that science rejects "my view" of the Bible. If the Bible itself pretended to be a scientifically accurate description of the events it describes, science would most assuredly reject its pretentions. But it does not, and so science is obliged to reject the pretentions of those who claim infallibility for it; as it does and must the claim of any authority to inerrancy and infallibility. Science, indeed, knows nothing of either the one or the other.

Science, as I have said, claims or should claim the entire realm of the knowable. In its beginnings it looked out upon this realm with a conception of its own ignorance. It discovered that the mind of man, by the application of a certain method of its own devising, is capable of dispelling this ignorance. It, therefore, set to work and, by systematic application of its method and strict adherence to it, sought to extend the area of knowledge. It has done so. But in doing so, it has met continually the opposition of those who contend that true knowledge may be acquired by more easy-going methods—by the methods I have already mentioned: by passive contemplation, by consulting oracles, by divination, by casting lots, by star gazing and a thousand and one other modes of arriving at the truth without the trouble of patiently assembling and studying the facts and drawing valid inferences from them. All such methods it brushes aside. It meets the contention that the so-called sacred books of the world, or some particular one of them, contain a divine revelation of the truth, making it unnecessary to explore, to investigate and to reason from established facts. True to its method, it proceeds to study these books in exactly the same manner in which it studies other phenomena. The so-called higher criticism of the Bible, for instance, is nothing else and nothing more than the application to its study of the spirit and methods of modern science. It has reached the conclusion, at least on the part of many of its devotees, that there is no book in the world that does not contain error, and the Bible is no exception. It also admits that there is none of the sacred books of the world that does not contain much truth. But it accepts no book as a final authority. Its final appeal is to facts, always to facts. It has constructed a method of investigating facts, and a logic of thence deriving laws and principles. On these it must rely. Science must go "on its own."

This does not express the view of all scientists. Some, there are, who seem to think, even assert, that the scientific method is not the only method of ascertaining truth, and they point to the method of experience. But in so far as experience discloses truth, it must be reckoned as a part of the scientific method.

Science, then, if and whenever it

manifests a disposition to take short cuts to the truth, or to take possession of it without the toil of investigation, will always be thrown back upon its fundamental and approved assumption that knowledge is to be gained only by the exercise of the mind in the investigation, by the most reliable method, of the facts of nature and reasoning from these facts as a basis. "The free employment of reason, in accordance with scientific method," said Huxley, "is the sole method of reaching truth." If labor is a curse, as it is not necessarily, then indeed is there a curse on science, for only in the sweat of its face shall it eat the bread of truth.

In concluding this aspect of our subject, we may repeat that science does not, and from its very nature can not, admit that either the Bible or any other book is inspired in the sense of being dictated by Omniscience, nor will it recognize the existence of a divine revelation as claimed by the church. There is, therefore, no possible reconciliation of science and religion on this ground. It should be recognized, once for all, that to this it must finally come, that theories of inspiration implying infallibility in anything belong to the childhood of the race and can never be accepted by science.

Science and Religion as Different Realms

There is, however, another species of attempted reconciliation between science and religion which must now engage our attention. It is found in the idea that science and religion are concerned with different kinds of truth, that they occupy different realms, and that there is, therefore, no necessity of any conflict between them. They are to be reconciled by dividing the universe and allotting to each its part. Religion, it is said, is concerned with only transcendental conceptions, God and man's relation to Him, for instance; while science is interested only in material phenomena. It explains such phenomena by reducing them to natural causation; but religion seeks final explanations; that is to say, science deals only with secondary causes, while religion deals with final causes. Religion, therefore, should leave the field of natural causation to science, and science should not interfere with religion in its speculations concerning God and man's relation to Him. Thus a *modus vivendi* between them is to be established by a sort of truce; they are to agree to let each other alone.

The classical example of this sort of attempted reconciliation is that presented by Herbert Spencer in the early chapters of his "Synthetic Philosophy." It is briefly as follows.

Religion is primarily concerned with the cause behind phenomena. From the beginning, however, it has professed to know the nature of this cause, interpreting it in terms of human personality. All gods have by it been represented as manlike, anthropomorphic. In so far as it has claimed positive knowledge, it has trespassed upon the province of science. Science has compelled it to give up one after another of its dogmas, and will continue so to do until its idea of the first cause is shorn of its anthropomorphic attributes, and yet its primal assumption remains as a necessary element in the human consciousness. Religion is thus reduced by Spencer to the consciousness of a mystery behind phenomena which the human mind is not able and never can be able to solve.

On the other hand, science, which limits itself to the field of phenomena, is equally compelled to recognize that all its facts and all scientific knowledge merge into the inconceivable or unthinkable, the postulate of religion. It is bound to recognize that all its explanations are approximate and relative. It can offer no final explanation of anything more than can religion. When science becomes fully convinced that its explanations are approximate and relative, that all its facts are in their ultimate genesis unaccountable and super-

natural, and when religion becomes fully convinced that the mystery it contemplates is ultimate and absolute, then, according to Spencer, a permanent peace between religion and science will be established. "Religion," he says, "has, from the first, struggled to unite more or less science with its nescience; science has, from the first, kept hold of more or less nescience as though it were a part of science. Each has been obliged, gradually, to relinquish that territory which it wrongly claimed, while it has gained from the other that to which it had a right; and the antagonism between them has been an inevitable accompaniment of this process." This antagonism will continue, he thought, until each fully recognizes its rightful limits. Or, to put the matter in another way, science as well as religion involves a consciousness of an incomprehensible power, an infinite and eternal energy called omnipotent from our inability to assign its limits, the consciousness of which is common to both, but the nature and attributes of which are incomprehensible to our finite minds. Thus both science and religion are reducible to a single form of consciousness. Consciousness, under one aspect, constitutes science; under another aspect it constitutes religion. Both are thus concerned with different spheres. Let religion confine itself to its proper sphere, namely, the supernatural, and science to the realm of natural phenomena and all will be well.

This form of reconciliation, as Ward remarked, "vividly recalls the manner in which the man is credited in the story when dividing his house with his wife, taking the inside for his portion, and allotting the outside to her!"[3] It is not probable that religion will be content with this division. There is plenty of room on the outside, but not much to challenge profitable thought; for in that ethereal region nothing, according to Spencer, can positively be known. Speculation alone is left to religion.

[3] "Dynamic Sociology," Volume 1, p. 156.

Notwithstanding the fact, then, that from Spencer's viewpoint religion and science are necessarily correlatives, standing for antithetical modes of consciousness that can not exist asunder, and notwithstanding the fact that it gives religious sentiment the widest possible sphere of action, there is not any likelihood of a reconciliation unless religion is brought back inside the house and the interests of both are united. This, I believe, can be done.

Science and Religion Defined

Before attempting to suggest how it can be done, let us take a glance at the essential nature of science and religion.

Science is concerned with knowledge—all knowledge. It is usually defined as tested knowledge which, in the various sciences, comes to be organized, classified and used for further discovery. Naturally the conception of science includes the method employed as well as the results. We properly speak of "the scientific method." There are, however, two prevalent misconceptions of science. They concern both its results and its scope. In the first place, since the aim of science is truth, that is, exact correspondence of scientific statements with reality, it is often spoken of as if it had attained this aim, that is, that at least in certain sciences we have accumulated a body of knowledge that is exact. We have what are called "the exact sciences." And so it is by some assumed that science in general is a body of truth that is fixed, established and unchangeable. This, however, is an error. It exceeds the claim of science. There is, in fact, no such thing as an "exact science," in the precise meaning of that term. Sciences have attained different degrees of exactitude in proportion to the complexity of the facts with which they deal. Some are more exact than others, but none of them is warranted in claiming for its pronouncements more than approximations to the truth. In physics, for example, scientific concep-

tions of the atom have had to be revised, and will perhaps be revised again. Mathematics, the most exact of all the sciences, finds itself contemplating a necessary adjustment to new theories of time and space. Every truth of science must be held subject to modification by new and wider generalizations. Those who desire absolute certainty will be disappointed if they turn to science. Indeed, disappointment must be their fate wherever they turn. For, in a universe that stretches into the infinite, there can be no such thing as a complete body of truth that is fixed and unchangeable. Infallibility when claimed for science is just as objectionable as infallibility claimed for religion. Once more, and now in the language of Huxley, "of infallibility, in all shapes, lay or clerical, it is needful to iterate with more than Catonic pertinacity, *Delenda est.*" Science is always changing, adapting and growing. It is knowledge and a particular method of ascertaining it. In the various sciences it presents bodies of knowledge as nearly exact as men have thus far been able to make them by a method of investigation as nearly perfect as man has thus far been able to devise. Its results, however, should always be regarded as more or less tentative, more or less imperfect, and more or less symbolic.

The second misconception in regard to science, and it appears to be entertained by some scientists themselves, is that science is concerned only with so-called material phenomena. At first it was supposed to be limited to the study of physical phenomena. Its field has been extended, rather slowly and grudgingly, to biological and psychological phenomena. Only recently, and still more slowly and grudgingly, has it been extended to social phenomena. But it ought to be obvious that science is equally concerned with all these fields, and not merely with a description of the facts there found, but also with the relations and interpretation of these facts as well; not merely with laws and principles, but with the observation of laws and the application of principles. In its higher generalizations, it is sometimes called philosophy, but it is "scientific philosophy," and differs from metaphysics in that it confines itself to the knowable. Social phenomena, then, social relations, right conduct, the good life and the relation of accurate knowledge thereto, all values and ideals so far as they have a social reference, are properly subjects of scientific study, just as legitimately so as atoms and molecules, the earth and the stars. Since morals obviously have, and religion quite as obviously may have, a social reference, morals and religious values and ideals, their origin, development and validity, should also be regarded as the subject of scientific study and of scientific evaluation. There is, perhaps, no greater social need to-day than that science should be extended to its legitimate limits, namely, to everything that can be known.

Religion, on the other hand, is not so much concerned, or at least not primarily so much concerned, with knowledge as with desire. Science is knowledge, religion is an attitude. I have defined religion as "the effective desire to be in right relations with the Power manifesting itself in the Universe."[4] It had its origin in the desire of the primitive man to be in right relations with mysterious powers whose existence he wrongly inferred from the phenomena of nature. Very early he was led to the belief that these powers were the dead who still lived on in the form of ghosts. The ghost of his ruler became his God. By a natural process, well understood by students of comparative religion, his gods were integrated, and polytheism became monotheism. Conceptions with regard to the nature and attributes of God have undergone a gradual process of evolution, also well known by all stu-

[4] "Work and Life," New York, 1913, p. 264.

dents of the history of thought. In every stage down to the present such conceptions have been anthropomorphic. At first, and quite naturally, very low qualities were attributed to the Deity. The conception depended upon the character of the people who entertained it. To-day, with many people, all these anthropomorphic conceptions are unsatisfactory and have been given up. We hear, now, of an immanent God, although this conception is rightly regarded as vague. The terminus of this evolution of man's conception of God has been indicated both in science and religion, namely, the consciousness of a power manifesting itself in the universe, but so far transcending man's knowledge that it is forever beyond his comprehension. He can not be sure whether it is personal or impersonal and, as Spencer remarked, he has not to choose between the two; it may be superpersonal.

> Is it not just possible [he says] that there is a mode of being as much transcending intelligence and will, as these transcend mechanical motion? It is true that we are totally unable to conceive any such higher mode of being. But this is not a reason for questioning its existence; it is rather the reverse. Have we not seen how utterly incompetent our minds are to form even an approach to a conception of that which underlies all phenomena? Is it not proved that this incompetency is the incompetency of the conditioned to grasp the unconditioned? Does it not follow that the ultimate cause can not in any respect be conceived by us because it is in every respect greater than can be conceived? And may we not therefore rightly refrain from assigning to it any attributes whatever, on the ground that such attributes, derived as they must be from our own natures, are not elevations but degradations?[5]

When the truth is perceived that God is incomprehensible and that man's speculations with regard to his relation to God must necessarily remain speculations, it will also be perceived that religion may properly be defined as the desire to be in right relations with the highest ethical conception of human life, a conception that can be determined by science as applied to the study of individual and social phenomena. Science may, and will, substitute for vague and always unverifiable ideas of the power behind phenomena, as a criterion for right action, a thoroughly reliable scientific conception of the social conditions necessary to the highest development of man's personality and his happiness. The effective desire for such conditions must necessarily generate a desire for the knowledge necessary to realize them; and since the scientist, like every one else, may be expected to have some interest in his own happiness, only to be attained by the application of science, he will be equally interested in assuming and in promoting the personal attitude by which alone it may be reached. Desire and knowledge will function to a common end.

A Suggested Reconciliation

Suppose, then, that religion should abandon the idea of a divine revelation of the truths of science, and of the possibility of comprehending the Infinite, as it will be obliged to do; and suppose that the field of science is extended to cover the entire realm of phenomena, including the social, moral and religious, as well as material phenomena; and suppose further that upon the basis of a scientific knowledge of the materials and forces of nature and the possibilities of achievement, a social ideal should be scientifically constructed. Now, since religion is professedly interested in the realization of the Kingdom of God, that is, an ideal society, it will see the necessity of scientific knowledge as a means of effort in its attempt to realize that ideal. As a matter of self-interest, it will offer every possible encouragement to scientific investigation in every possible field. Religion will thus become scientific.

On the other hand, if science recognizes, what is plainly the truth, that it

[5] Spencer's "Synthetic Philosophy," "First Principles," Vol. 1, p. 109.

is concerned or should be concerned not alone with material phenomena, the field of so-called natural science, but the realm of so-called spiritual phenomena as well, that is, the phenomena of morals, religion, ideals, values, etc., then it must also perceive that its work is not complete when by means of the scientific method it has discovered a fact, a law, or a principle; but that it must manifest an interest in the practical, that is, scientific, application of these discoveries in the construction of an improved society. Science and religion, then, interested in a common purpose and each being dependent upon the other for the realization of that purpose, their reconciliation must obviously come about. Thus science becomes religious and religion becomes scientific. This brings the two together in a common aspiration, a common interest, and a common effort. They cooperate rather than compete.

Conclusion

If it be said that this is religion without a God or the Bible, I should not feel obliged to admit the contention, although a religion without a God is not merely conceivable but is a fact, as in the case of Buddhism. But what is here proposed merely means that both science and religion shall agree upon the idea that the cause behind phenomena is incomprehensible. They do, in fact, agree upon this point. "Canst thou by searching find out God?" Furthermore, that they agree, God or no God, that human happiness is the end to be attained; and that they perceive, as they must perceive, that, in any effort to reach the end, science is helpless without religion, and religion is helpless without science. They must function together—ideally, of course, in the same personality. This leaves scientist and religionist to speculate to their heart's content about the nature of the great cause, the ultimate nature of reality, the ultimate meaning of life, etc., but the immediate concern of each will be the scientific organization of human effort to promote the advancement of society in the direction of a scientifically constructed social ideal. This will be their religion. "That a man should determine to devote himself to the service of humanity," said Huxley—"including intellectual and moral self-culture under that name; that this should be, in the proper sense of the word, his religion—is not only intelligible, but, I think, a laudable resolution." And he adds that he is "greatly disposed to believe that it is the only religion which will prove itself unassailably acceptable so long as the human race endures."[6]

As for the Bible, as I have already shown, there need be no more thought of discarding it than of discarding any other great human document in which ideas and ideals are set forth. Nor need we fear the loss of a single truth it contains.

> One accent of the Holy Ghost
> The heedless world hath never lost.

But, at any rate, you say, this means a religion without the ordinary or orthodox conception of God and of the Bible. Be it so, a religion which will really unite all men in the service of the ideal and eliminate friction and strife, which are both wasteful and irreligious, is infinitely better than a religion which divides mankind into irreconcilable religious groups on the one hand and of scientists on the other.

Science and religion together, then, must build the future. Every stone that is used in the construction of the ideal social temple, that does not accidentally fit into the structure, must be quarried and fashioned by science; it must be laid in the spirit of love and service, that is, in the spirit of true religion. True science and true religion are really one, as means to human perfection. They must be recognized as such before they can be finally and permanently reconciled.

6 "Science and Christian Tradition," New York, 1899, p. 255.

A SUMMER ON LOGAN RIVER

By Professor JAMES G. NEEDHAM
CORNELL UNIVERSITY

On Logan River in Northern Utah in 1926 my ideal of a summer in biological work was realized. I taught in the National Summer School at Logan, but I lived on the river in the heart of Logan Cañon nine miles in the mountains. I took my classes to the river. We collected from its shining ripples, its foaming rapids and its shady pools. We visited the cold springs high up the mountains at its source. We followed it down upon the desert plain. From the crystalline shallows of its upper reaches down to its warm muddy basins below the irrigated fields we followed its changes and gathered samples of its life. The river was our text-book.

Between class sessions I studied the life of the river. I collected from every sort of situation it offered. I reared nearly all its hitherto unidentified insect larvae and returned home heavy laden with the summer's spoils.

There were several conditions that were unusually favorable. It was a season of low water, which made for good collecting. There were no mosquitoes. I lived in Professor A. J. Hansen's cottage at Birch Glen, and it was equipped with everything I needed for my work. It stood near a bridge under which I found a place of safety for my rearing cages. Not a cage was molested all summer long. It was located above all power and irrigation developments where the stream is quite natural. I had for a partner and helper Mr. Reed Christenson, and his automo-

A COLLECTING PARTY IN THE BEAR RIVER RANGE
Left to right, the author, Dr. George R. Hill, Mr. D. F. Heywood, Dr. F. P. VanDuzee, Mr. Loring Richards and Dr. I. M. Hawley.

WHITE PINE LAKE IN THE BEAR RIVER RANGE
UPPER LOGAN RIVER VALLEY, UTAH. ALTITUDE, APPROXIMATELY 8,500 FEET.
Photo by M. B. Linford.

bile in the course of the summer ran some five thousand miles on collecting trips that we took together.

Logan River is a beautiful mountain stream. It rises at some eight thousand feet elevation in the Bear River range of the Wasatch Mountains and emerges on the plain of the Cache Valley at about four thousand five hundred feet. In its upper reaches the bordering slopes are overspread with fields of sage and groves of aspen. These thick clustering groves are very beautiful: the trees seem as gregarious as the sheep that are herded in the intervals between. The edges of the sage clumps are ornamented with scarlet castilleias and with goldenrods; and the frequent moss-grown springs are bordered with yellow monkey-flowers. Their outflowing brooks are choked with water-cress.

Farther down the river winds through a deep cañon, whose rocky walls between the jutting gray ledges are overspread with a low silvery drapery of sage, or with a taller but equally silvery cover of mountain mahogany. Here and there are tuftings of the richer green of cedars on the southern, and of spruces on the northern exposure. Tall summits of bare rocks rise like battlements distantly, often seeming to be carved by wind and weather in architectural columns.

The floor of the cañon at Birch Glen (four thousand nine hundred feet) is covered with trees. Clustering birches and willows border the stream. Interspersed clumps of red-berried elder flowered beautifully in June, and later the wild clematis spread its white blossoms everywhere in charming confusion.

The river itself here flows steadily over a bed of stones, with no falls and with hardly any scour-basins or sand bars. At the bridge where our rearing work was done, it is deeper and its surface is wrinkled rather than rippled by the slackened flow; but near at hand are rocks and foaming rapids.

This is a wonderful trout stream. I never saw so many anglers in so small

OVERHANGING ROCK

ON THE RIGHT FORK OF LOGAN RIVER ABOVE THE BOY SCOUTS' CAMP.

a space. There were literally hundreds of fishermen. They were fishing at all times and few there were among them who did not catch trout. There were mountain herring also, *Coregonus williamsoni*, in the stream, though I did not see any of them caught. Kingfishers flew occasionally up and down the river and bobbing water-ouzels stood upon the rocks, courtesying, or made sudden dashes underneath the rapids.

The stream abounds in stoneflies and mayflies, and these feed the trout. From one square yard on the abutments of the bridge at Birch Glen I picked the cast skins of 113 stoneflies; and 82 of these were skins of the big fellow, *Pteronarcys californica*, near two inches long. This great, lumbering, black, archaic insect was flying everywhere on the lower river by the end of June. Females would fly out into the green lane between the trees over the river, slowly flopping their broad wings, Pterodactyl-like in aspect, and without stopping or descending at all, would release a roundish cluster of eggs that would fall like a raindrop into the stream. Thus is the food-supply of the trout renewed.

I reared ten species of mayflies at Birch Glen—some of them very common and very important as forage organisms. One of these (since named by me *Rithrogena fraterna*) was a remarkably pretty nymph, having gill plates of rose-red color arranged as a fringe around its body to form a sucking disc, by means of which it adheres to smooth stones in the swiftest waters.

There was genuine interest on the part of my classes in finding these and other things, and in participating in a pioneer work of exploration. There were temperature preferences observable in the stream. There was an entire change of

FIG. 1. SKETCH MAP OF LOGAN RIVER

BLACK CIRCLES INDICATE PRINCIPAL COLLECTING PLACES. FIGURES GIVING ALTITUDES ARE ONLY APPROXIMATE. TEMPERATURES OF SOME OF THE COLDER WATERS ARE GIVEN IN DEGREES FAHRENHEIT WITH A LINE DRAWN AROUND THEM.

WHITE PINE LAKE

AND THE SNOW FIELDS BEYOND IT, AS SEEN FROM THE RIDGE ABOVE. *Photo by M. B. Linford.*

fauna with the emergence of the river from the cañon onto the plain. There were examples of altitudinal distribution, as marked as those of the trees upon the slopes. The accompanying sketch map shows where we held class sessions on the river.

We left the river for two afternoons at Dry Lake in the farther (southern) rim of the Cache Valley. One trip was made on June 24th, when the water was low (maximum depth about eighteen inches). The other was made July 22nd, when the water was almost gone (maximum depth about six inches).

This lake occupies a little basin between low mountain tops at an elevation of five thousand six hundred and sixty feet. It fills with the melting of the winter snows and is then a mile or more across in any direction. Its waters disappear entirely in the late summer, and a crop of wild hay is cut from the peripheral portion of its bed by the farmers who own the land.

There were a few acres of open water at the time of our first visit in June. Some clumps of lake bulrush emerged here and there and waterfowl were abundant in their shelter. Surrounding

FIG. 2. DRY LAKE, UTAH, THE HOME OF THE PADDLE-TAIL, *LEPIDURUS COUESII*

THE ABOVE IS A COPY OF WHAT MY FRIEND, PROFESSOR ALFRED C. BURRILL (WHO WAS WITH ME AT DRY LAKE) CALLED A "PANTOGRAPH DISTORTION" AND ENLARGEMENT OF A PORTION OF THE LOGAN QUADRANGLE, U. S. GEOL. SURVEY, WITH THE OGDEN-TO-LOGAN STATE HIGHWAY ADDED; ALSO WITH ZONATION ON LAKE BED AS FOUND BY US ON JUNE 24TH. THE CROSSLINED AREA WAS DRY. THE STIPPLED AREA WAS SPIKERUSH IN VERY SHALLOW WATER (DRY ON OUR LATER VISIT). THE INNERMOST AREA WAS OPEN WATER WITH CLUMPS OF LAKE BULRUSH ("TULES").

A FALLEN GIANT

OF THE BULL CREEK REDWOOD GROVE. JOHN T. NEEDHAM, CUSTODIAN OF THE MUIR WOODS NATIONAL MONUMENT, STANDING BESIDE IT. CALIFORNIA, 1923. *Photo by J. G. Needham.*

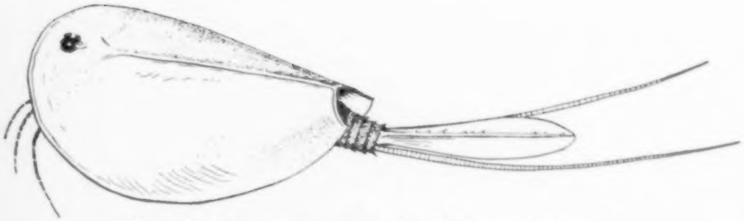


FIG. 3. THE PADDLE-TAIL, *Lepidurus couesii* × 2.

the open water was a very broad belt of bright green meadow, composed of spike rush (Eleocharis), in very shallow water. Numberless damselflies (*Lestes uncatus*) were emerging, and their cast nymphal skins were hanging on the rushes everywhere. The unique phyllopod crustacean, *Lepidurus couesii*, was quite common, though already disappearing. When we returned in July this was gone and the water was gone from the spikerush zone, and the bladderwort, *Utricularia vulgaris*, had shot up tall peduncles of bright yellow flowers. What a place to study seasonal succession if only one were there!

But we only visited Dry Lake. We lived on the river. And it was another source of satisfaction to me to see the members of my class quickly discovering how easy it is to pick up some real knowledge of the life of a stream. Trout fishing is a principal sport of residents in Cache Valley in the summer time; and the fishing is not so good as once it was, when the dangling lines were fewer. What can be done about it? is the common question; and while there are many answers there are none that are solidly based on facts. There is plenty of guessing. My classes went fact-finding. It was quickly apparent that food was not the limiting factor at Birch Glen, as had been supposed. The river teemed with the best of forage organisms, nymphs of mayflies and of herbivorous stoneflies; and the trout were fat. Other parts of the stream were full of competing carnivores and the trout were lean and ill-conditioned.

So the work of the summer included this contact with the practical interests of the people. For purposes of instruction it used only local materials; none better could have been found. It yielded scientific results of some value. It all met with the friendliest cooperation; and it was done amid scenes of novelty and beauty. Would that there were more opportunities in America for combining the teaching of classes (for which alone we get paid) with research in the field.

TRANSATLANTIC TELEPHONY[1]

By Dr. FRANK B. JEWETT

VICE-PRESIDENT OF THE AMERICAN TELEPHONE AND TELEGRAPH COMPANY

As long distance radio telephony sprang much more directly than is commonly realized from experiments and actual experience with long distance wire telephony, I will relate a little history very briefly. About the year 1890, the type of pole line structure that New York City required for its long distance telephone service was that of Figure 1. The poles of this line were some ninety feet high and at some points carried thirty crossarms and, therefore, three hundred wires. While there is something about these poles that seems to remind one faintly of the sail plan of a Chinese junk, they were not deemed sufficiently artistic to warrant their being continued in use any longer than was absolutely necessary. They had many disadvantages from the standpoint of the telephone engineer; nor was their presence particularly appreciated by the city fathers of Manhattan. One of the troubles to which this type of line is heir is well illustrated in Figure 2, which shows the destruction that sleet and wind can work in the course of a few minutes.

Intensive research was, therefore, undertaken to find some more desirable telephone line structure than that afforded by these enormous poles. Passing over many intermediate types of long distance line which have been employed at various times and places, let us consider one of the most approved forms yet devised. Its outward appearance is shown in Figure 3. Within a thin lead sheath, about two and a half inches in diameter, many wires are closely packed together, each being insulated by a very thin covering of paper. The particular cable shown here in section contains about 550 wires and, therefore, nearly twice as many as the tall poles of Figure 1. This cable can, of course, be mounted on short rugged poles so as to make it immune to damage by storm, or where desired, it can be placed underground. Bearing in mind that this single cable contains wires enough to form hundreds of individual telephone circuits, you will realize at once that as a structure it represents a great advance. But this is only half the picture, for its electrical advantages are as pronounced as its structural advantages.

Indispensable in connection with the operation of such a cable, as well as of all long distance lines, is the telephone current amplifier, generally known as the telephone repeater. It was as long ago as 1905 that an early model of a repeater was inserted in the line then running between New York and Chicago. The action of this repeater was equivalent to shortening that 1,000 mile line by 300 miles. It marked the beginning of long distance telephony, and with this success behind, we knew it to be possible to telephone over great distances both by wire and by radio. In both these undertakings, the fundamental requirement was an amplifier which would raise the energy of the telephone currents without adversely affecting the intelligibility of the message.

We naturally turned our attention first to the development of long distance telephony over wires, and in January, 1915, the first transcontinental circuit connecting New York and San Francisco

[1] Based on a talk given before the National Academy of Sciences, Washington, D. C., April 25, 1927.

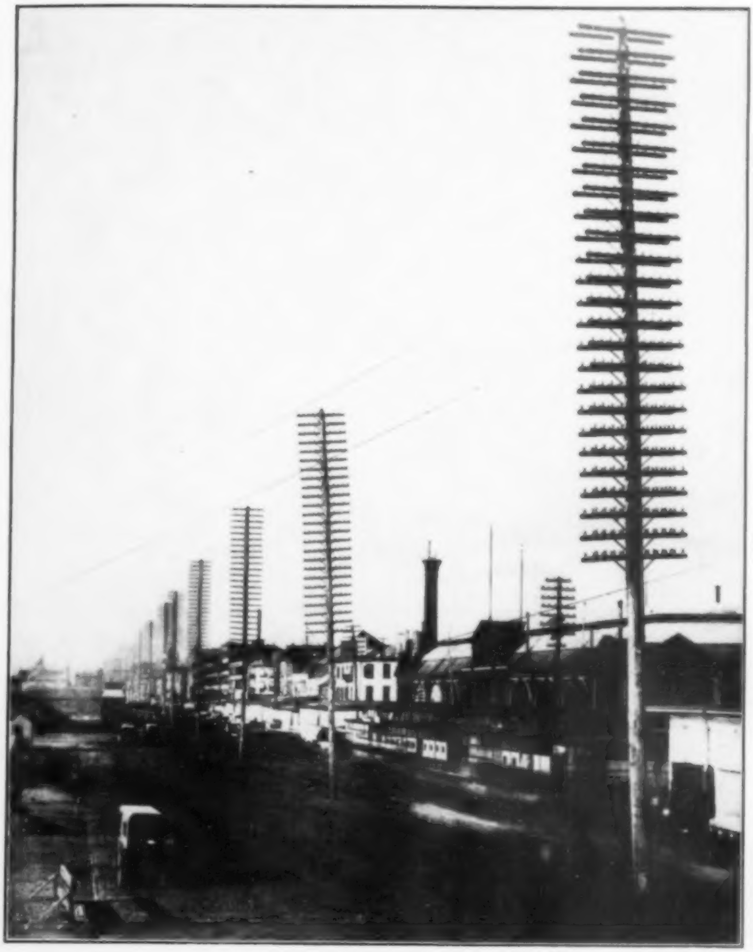


FIG. 1. WEST STREET POLE LINE, NEW YORK CITY, ERECTED IN 1887
90-FOOT POLES, 25 CROSS ARMS, 250 WIRES. AT SOME POINTS IT CARRIED 30 CROSS ARMS AND 300 WIRES. THE PICTURE WAS TAKEN AT THE FOOT OF CORTLANDT STREET.

was opened for service. By good fortune, however, the vacuum tubes used in the transcontinental repeaters proved applicable in several important ways to radio telephony. This is well attested by the fact that in the same year we were able to announce the successful transmission of the voice by *radio* both across the American continent and across the Atlantic Ocean to Europe.

Turning our thoughts back twelve years, we recall that none of the now familiar aspects of radio telephony had put in an appearance. Radio telephony was first used as an instrument of military character by the various armies engaged in the World War about 1917, and broadcasting was probably born about 1920. However, in our search for new instrumentalities of communication, the engineers of the Bell System had arrived in 1915 at the stage which made it possible for them to transmit the voice by radio telephony over a distance as great as 5,000 miles. By means of transmitting apparatus located at Arlington,

FIG. 2. OPEN WIRE TOLL LINE AFTER SLEET STORM

FIG. 3. CABLE RUNNING THROUGH VALLEY

Virginia, we succeeded in sending intelligible speech across the continent to San Francisco and also as far westward as Honolulu. A few weeks later, two of our engineers who had been sent to France, succeeded in receiving speech from Arlington, making use of a receiving antenna located upon the Eiffel Tower in Paris.

While the demonstrations of 1915 were purely experimental, they yielded important results. On the one hand, they proved that transatlantic telephony was in the realm of the possible, and on the other, it gave our engineers a much clearer insight into the difficulties which they would encounter were they to attempt to offer regular telephone service to Europe. In fact, these difficulties stood out so prominently as to leave no doubt that before commercial transatlantic service could be offered, a very extensive program of development and study would have to be completed. It is in this connection that the problems of the applied scientist arise. It was apparent that such a program would not be a matter of months but years, and could not be launched at all while the World War was in progress. Some three years later, however, it was begun and has continued down to the present without interruption.

Even now that regular service to England has been inaugurated, our studies are continuing. This is but one detail of a continuous program of study and improvement. Thus, we have been offering wire telephone service for fifty years, but we are to-day studying its instrumentalities more intensively than ever. I think it can be safely predicted that the more firmly established transoceanic telephony becomes, the more interested we will be in seeking out improvements of the apparatus that makes it possible.

I propose to recount briefly what we have to show as the results of a nine-year study of transatlantic telephony.

FIG. 3A.—PIECE OF CABLE WITH SHEATH PARTLY REMOVED
TO SHOW THE ARRANGEMENT OF THE WIRES

To-day, nearly everyone is familiar with the more superficial phenomena of radio, particularly radio broadcasting. But probably to most people, the term radio largely symbolizes the particular receiving set that they happen to make use of for picking up programs. To them, the phenomena of transmission and what goes on at a transmitting station are largely someone else's concern. To the telephone engineer, however, the term radio denotes a complete system comprising a sending station, the surrounding medium of propagation, a receiving station, and usually wire lines connected to both the sending and receiving stations. Then, of course, if the system is to be employed for two-way telephony (which alone would be capable of handling a conversation between two people) it must be extended to include two receiving stations and two sending stations

TRANSMISSION ANALYSIS OF RADIO CIRCUIT

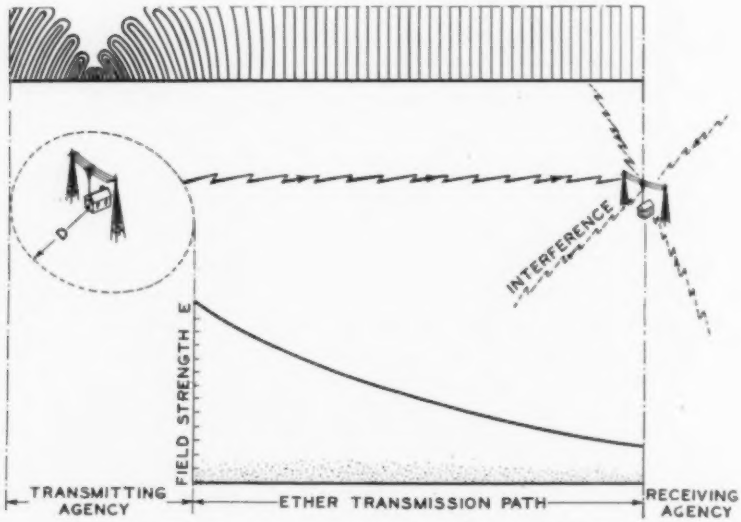


FIG. 4. DIAGRAM OF RADIO WAVES
SPREADING OUTWARD FROM A TRANSMITTING STATION; A SINGLE RECEIVING STATION IS SHOWN.

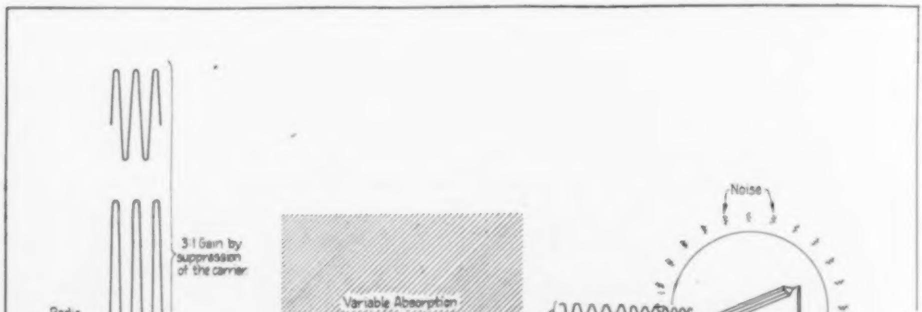


FIG. 5. DIAGRAM SHOWING MESSAGE ARRIVING
FROM THE DIRECTION OF THE TRANSMITTING STATION.

with means for properly connecting them together by wire lines.

In dealing with such a radio telephone *system* one is faced with the necessity, or perhaps it would be better to say offered the opportunity, of coordinating the various component parts to secure the best results. To show the improvements and the progress that become possible when the engineering of a complete system is undertaken, I will contrast, from time to time, throughout my talk, radio telephony as it exists to-day in the form of broadcasting with the radio telephone system which we are now employing for handling calls to Great Britain.

Let us begin by considering the simplest possible type of radio telephone system. Figure 4 represents a single transmitting station and a single receiving station, and at the upper margin the radio waves are illustrated as spreading outward from the former. As they travel outward they, of course, become fainter and fainter in some such manner as illustrated by the drooping curve below. Now it is unfortunately a fact that our receiving antenna is subject to undesirable radio influences—to interference—as well as to the single message which we want to pick up. Static is one well-known form of interference and the signals emanating from other stations, particularly telegraph stations, is another familiar form.

If it were not for interference in radio, the communication engineer's problem would be ever so much simpler than it is. Then it would merely be a question of transmitting the message through space and picking it up at the receiving point, regardless of how faint it had become; and should it be too faint to be readily heard by the ear, it would, of course, be a simple matter to amplify it enough to make it audible. In the presence of interference, however, it is necessary that the message, when picked up by the receiving antenna, be sufficiently intense to *override* that interference. Putting this matter more directly, one might say that due to the interference, it might be necessary to deliver the message to the receiving station with perhaps a million times as much power as would otherwise be necessary. In a very real sense then, the problem of the radio engineer becomes one of combating ether interference.

In the first place, by treating the transatlantic system as a whole, we have been able to effect a substantial gain in efficiency at the radio transmitter. By using the "suppressed carrier" system of transmission, the high frequency power generated by the transmitter is utilized *three times* as effectively as in broadcasting. Another development, known as single side-band transmission, has also augmented the efficiency of the transmitter and a little later I shall mention the gain resulting from this.

After the message leaves the transmitting antenna, it must pass through some 3,000 miles of the earth's atmosphere. Here it encounters a degree of absorption which varies from hour to hour, from day to day and from season to season. Over this transmitting medium man has, as yet, little if any control. Conditions existing at certain times, notably at night, are more favorable than those found at other times, and knowledge of such more or less systematic variations would enable us, other factors permitting, to carry on our exchange of messages at the most favorable times. But this is far from constituting control of the atmospheric influences and it will only be after more extended investigation and study, if at all, that we can devise a radio system in which transmission will be appreciably independent of such factors. It may be interesting to point out that in the present state of the art, the influence of the atmosphere is so great that while at times a very small amount of power will suffice to get a message through, only a few hours later 10,000 times as much

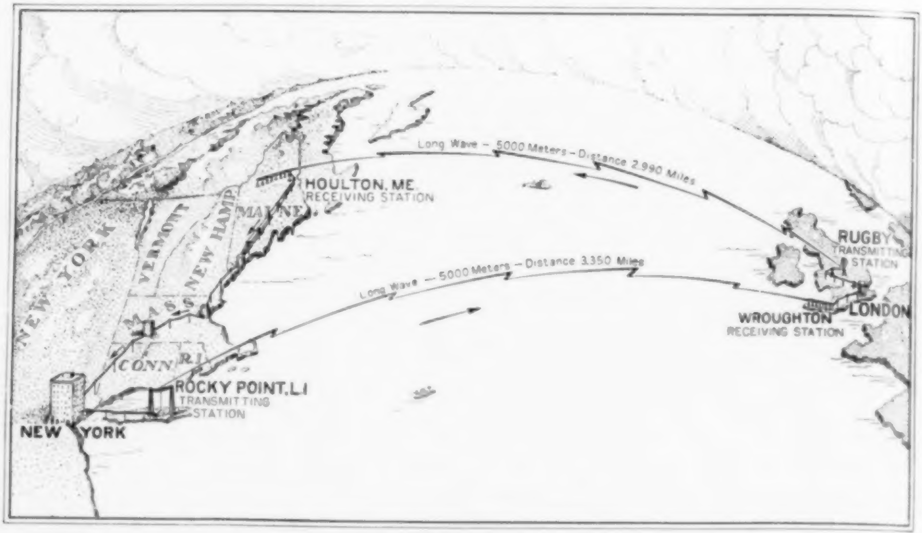


FIG. 6. MAP OF THE WIRE AND RADIO LAY-OUT FOR TRANSATLANTIC MESSAGES.

power may be required. As a matter of fact, the transmitters are operated at constant full power. Under good conditions, this allows a margin of safety; under very poor conditions it may be insufficient.

When we reach the receiving station we are at the scene of many notable achievements. Figure 5 has been so drawn as to show the desired message arriving from the direction of the transmitting station, and it also shows the receiving antenna under the influence of interference or noise coming from all directions, of course including that from which the message comes. It is apparent from the drawing that if, *in effect*, we could surround the receiving antenna by some sort of a shield which is open only in the direction from which the desired messages come, we could eliminate a large part of the interference. This result has been accomplished, not by enclosing the receiving antenna in a screen, but by so designing the antenna itself that it is highly directional in its response, being virtually insensitive to signals coming from directions other than that followed by the message. So effective is our present antenna that as a device for discriminating in favor of the message and against the interference, it represents a one hundredfold improvement over the loop antenna now so commonly used in broadcast reception. Hence it is equivalent, from the standpoint of the transatlantic radio system, to a one hundredfold increase in the power of the transmitting station.

I mentioned previously that we are employing the single side-band type of transmission. This enables us, in effect, to narrow down by one half the opening through which the message is admitted to the receiving set. This decrease of the opening by one half works no hardship upon the message but does, of course, reduce by about one half the amount of interfering noise which would otherwise be picked up.

As another step, we found, after a long series of observations conducted along our Atlantic seaboard, that by locating the receiving station well north a decided improvement so far as freedom

FIG. 7. THE OPERATORS AT 24 WALKER STREET, NEW YORK CITY
WHO HANDLE THE TRANSATLANTIC TRUNK. POSITION 104 IS THE TRANSATLANTIC BRANCH AND 103 AND 105 ARE THE OPERATORS WHO HANDLE THE LINES TO THE LOCAL SUBSCRIBERS.

from interference is concerned, could be obtained. Our western receiving station is now located at Houlton, Me., well up in the northern corner of the state, and observations show that this secures for us something like a fiftyfold improvement over that to be had around New York or Boston.

Totaling up the effect of the developments which I have just described, we arrive at a surprising figure—by suppression of carrier a threefold gain; by single side-band transmission two more or six; by a northern site for the receiving station, fifty more or three hundred; and finally by the directional antenna one hundred more or a total of thirty thousand. That is, the transatlantic telephone system as it stands to-day is some 30,000 times as efficient as the best that there is available in the field of radio broadcasting. This does not mean that broadcasting systems are unsuited to the particular purpose for which they are used, but it indicates that something tremendously more efficient had to be developed for successful transatlantic telephony. This is a truly astonishing figure and well worth the years of study it has involved. But our studies are not over, for we believe that we have by no means reached the limit of possible improvements.

Figure 6 shows in diagrammatic form the wire-radio layout made available to a subscriber on one side of the Atlantic when he converses with a subscriber on the other side. The western telephone, connected by a wire line to New York City, may be any telephone in the United States. This wire line terminates in the long-distance headquarters in New York, from whence another line runs out Long Island to Rocky Point where the radio transmitter is located. Over the wire line the message travels as any ordinary telephone message. Upon reaching Rocky Point it must be prepared for the transatlantic jump and for this it is,

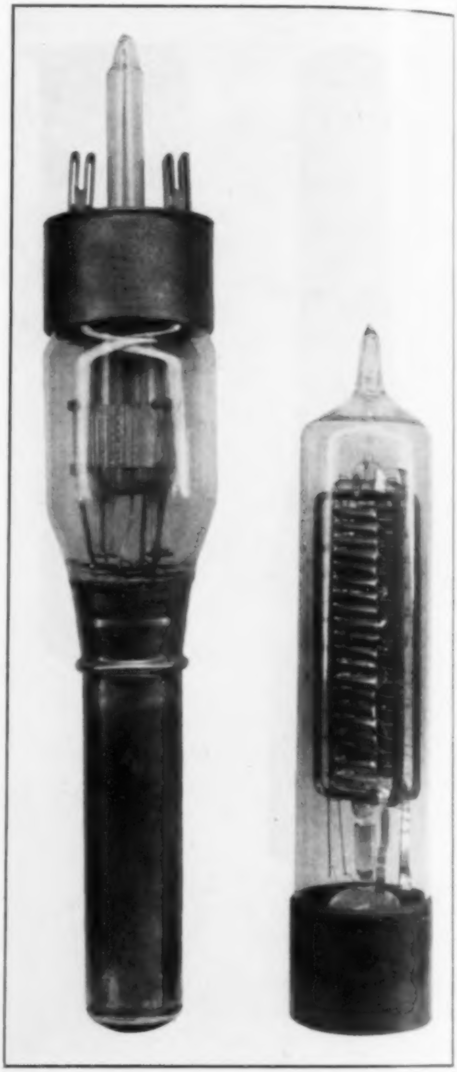


FIG. 8. THE TRANSATLANTIC VACUUM TUBE OF 1927

CONTRASTED WITH THAT OF 1915. THE TUBE ON THE LEFT IS THAT BEING USED TO-DAY, AND ALTHOUGH VERY LITTLE LARGER THAN THE ORIGINAL TUBE ON THE RIGHT, IT IS 400 TIMES AS POWERFUL.

among other things, amplified greatly—upwards of two billion times.

At Rocky Point the journey by radio begins, and if atmospheric conditions are

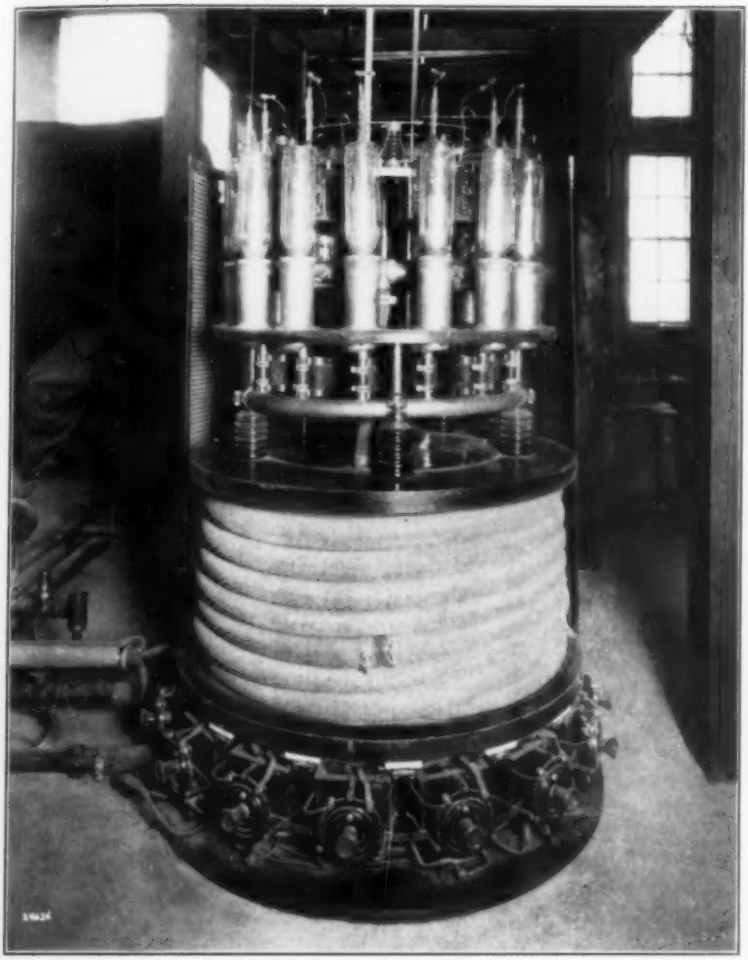


FIG. 9. WATER-COOLED POWER AMPLIFIER TUBES FOR TRANSATLANTIC RADIO TELEPHONY

not too unfavorable, will terminate successfully at Wroughton, England.[2] Here it is received and automatically relayed to a telephone line running to London and terminating in the long-distance headquarters there, from whence it goes by an ordinary telephone circuit to the British subscriber who may be anywhere in England, Wales or Scotland. As the Britisher speaks, his voice comes back over the same wires to London and thence over another telephone circuit to the town of Rugby, where the English radio transmitter is located. Here it undergoes enormous amplification, similar to that at Rocky Point, and is ready for the radio journey westward which terminates in the American receiving station located at Houlton, Me.

[2] The new British receiving station at Cupar, Scotland, went into service in May, 1927.

As previously mentioned, our experience shows that a receiving station located pretty well north is in a favorable position, and although every part of the British Isles lies north of Houlton,

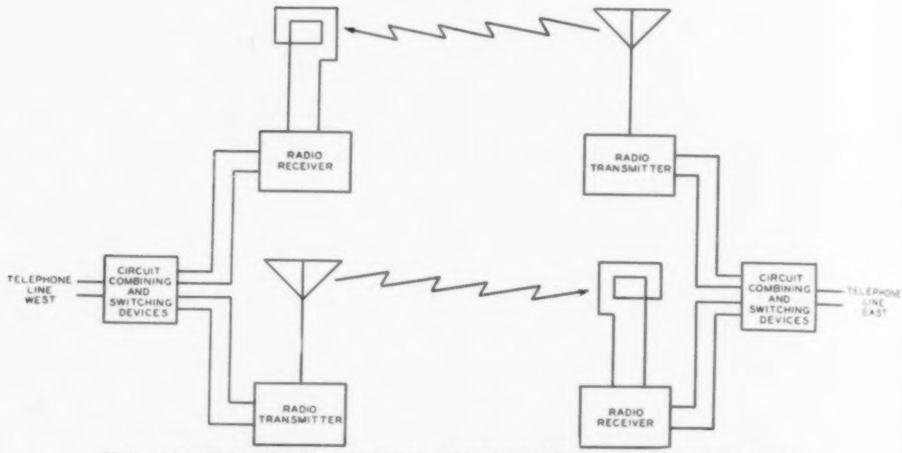


FIG. 10. DIAGRAM OF THE AMERICAN RECEIVING STATION
TUNED TO THE WAVE-LENGTH OF THE TRANSMITTING STATION.

the English are now erecting a new receiver in the north of Scotland.[3] From Houlton the message comes down over an ordinary telephone line to New York, and thence to the western subscriber.

Figure 7 shows a view of one of the long-distance switchboards in New York. Except for little labels in the frames at the top of this board, there is nothing to indicate that the messages being handled here go to England rather than to Albany or Syracuse. Three of the girls shown, however (those at positions 103, 104 and 105), are the so-called transatlantic operators. The center girl of the three operates the radio branch of the circuit, that is, she is in touch with a corresponding "telephonist" as the English call their operators in London. The other two girls are responsible for the recording of calls, the looking up of telephone numbers of persons who are called, and the setting up of the necessary wire circuits in this country to connect the subscriber with the radio link. A similar pair of girls are stationed in London for taking care of analogous duties there.

The success of the transatlantic service depends, in large measure, upon the high power vacuum tubes we have perfected.

[3] See preceding footnote.

Figure 8 gives an interesting epitome of power tube progress during the interval separating our first talk across the Atlantic in 1915 and the present. On the right is a sample of the tube we used in 1915; five hundred of these were operated as a single unit. On the left is the water-cooled tube of the present day, one of which is equivalent to 400 of the early tubes. About twenty water-cooled tubes are now used regularly and, therefore, supply some fifteen times the total power output available during our 1915 experiments and, of course, much more reliably. Figure 9 shows one of the amplifiers in which the present water-cooled tubes are used.

The girls who operate the transatlantic circuit have already been mentioned, but in a sense, the voice of anyone speaking over the transatlantic circuit is its own telephone operator, for there is at each terminus a little device so sensitive that the voice in passing through it throws it from one position into another and thereby accomplishes a most important result. Because of the limited number of wave-lengths available for transatlantic radio service, it is desirable to transmit the voice eastward on the same wave-length that we use for transmitting it westward. Referring to

Figure 10, that means that the American receiving station is tuned to the wave-length on which the American transmitting station is sending. Now the former must normally be in such adjustment as to receive the very faint signals coming from Rugby, but standing as it does relatively close to the American transmitting station, it would, save for special arrangements to the contrary, pick up very strong speech signals coming from this nearby station—signals so strong that they would virtually overpower the receiving circuit. Exactly the same situation would arise at the English terminus and for the same reason.

It is to prevent this that the voice as it travels over the circuit is called upon to effect a sort of switching operation. In Figure 10 two points are indicated at which switches are capable of connecting the subscriber's line, either to the transmitting station (talking condition) or to the receiving station (listening position). Now in the unexcited or quiescent condition, the two receiving lines are operative, that is, the switches are thrown so as to connect them to the subscriber's lines, while the two transmitting circuits are disconnected. It is these switches that the voices of the speakers operate. Suppose the American subscriber speaks. As soon as his voice reaches the long-distance headquarters in New York City a portion of it is caused to pass through a sensitive relay which thereupon operates. This relay moves the switch from the receiving to the transmitting position. Therefore, when the same voice emerges from its radio transmitter tremendously amplified, it finds the path back to New York along the receiving line blocked, since this line has been disconnected. After traversing the ocean it can enter the English receiving circuit since this is in its normal operative condition, and so travels to the English subscriber.

When the American subscriber ceases, his switch falls back to the receiving position, and as the English subscriber speaks, his switch is thrown from the receiving to transmitting position. His apparatus, therefore, can not pick up his own voice, but it can be picked up by the American receiving circuit, which became operative as soon as the American subscriber ceased speaking.

I shall conclude now, mentioning just one more thing that the voices of the speakers must do. Although they are not shown in the figure, there are similar relays in the two receiving circuits whose function is to make the complete system interlocking in the sense that when one subscriber is speaking, the other can not interrupt him. Thus so long as the relay in the English receiving line is under the influence of the American subscriber's voice, it locks the switch shown in the slide in the receiving position. Of course, this "lock" is immediately removed once the speaker stops, so that, so far as the subscribers are concerned, the circuit displays no inertia or delay.

I have attempted to describe in simple terms some of the rather remarkable things the telephone engineer can do with the devices that science has made possible, and, as a final word, I wish to quote a few lines from an old poem of Emerson's:

The lightning has run masterless too long;
He must to school and learn his verb and noun
Teaching his nimbleness to earn his wage,
Spelling with guided tongue man's messages.

In view of the details of operation of the transatlantic telephone, I believe you will agree with me that the lightning is making a very apt pupil.

THE SABER-TOOTH TIGER

By W. A. SPALDING

LOS ANGELES, CALIFORNIA

Before the age of ice had come,
  Before its glaciers planed the earth,
Before the streams were frozen dumb,
  Before the race of man had birth,

When this was still a tropic land,
  And trees and shrubs and plants were rank,
And water stood on every hand,
  With giant reptiles on the bank;

When mollusks bred in countless hordes,
  And strange, weird fishes swam the sea,
And saurians were winged, like birds,
  And mammoth lizards sported free;

And birds were few, and oft appeared
  As animals bereft of flight,
And giant sloths on haunches reared,
  And giant bats possessed the night—

Then roamed the saber-tooth at will;
  The terror of the jungle, he;
Armed as no other beast to kill,
  Fierce as no other beast could be.

The elephant imperial, tall;
  The mastodon of ponderous weight;
The sloth, full-armored over all—
  Were helpless victims doomed of fate.

Fate and the saber-tooth were one,
  Asserting undisputed sway;
For evolution, just begun,
  Was strong and cruel in that day.

But nature, from her fearsome first,
  Brought recompense for evils all,
And utilized her lowest, worst,
  To work her ends—to bring their fall.

And nature hath her quiet ways,
  The fierce and strong to overmatch;
And nature watches nights and days,
  And nature's trap is set to catch:

A quiet pool in shady nook,
  A cool, inviting solitude,
Thence running forth a little brook,
  Meandering seaward through the wood;

But, on the basin's shallow floor,
  And reaching forth beyond its brink,
An oily ooze—who ventures o'er
  Must flounder here, and sink.

And hither come the foolish herd—
  The small and weak, the great and strong—
By fate of others undeterred,
  In purblind urge they march along.

And hither comes the tiger, too,
  Attracted by their frightened cry—
* * * * * * *

But that was eons-gone ago—
  In asphalt-bond their fossils lie.

THE PROGRESS OF SCIENCE

EDITED BY DR. EDWIN E. SLOSSON
Director of Science Service

HOW BIG CAN A STAR BE?

THE first star to be measured five years ago, Betelgeuse, proved to be so large that it quite cast our own sun in the shade, speaking metaphorically. For its volume is some fifty million times that of the sun. But if we compare mass instead of measure we need not feel so much ashamed of the bright particular star to which we are attached. For if the two stars could be put into balance pans, Betelgeuse would be only some fifty times heavier than our sun. If now we divide the weight, 50,000,000, by volume, 50, we find that the average density, or specific gravity, of Betelgeuse is about a million times less than that of the sun. This red giant star is therefore a mere gas-bag—minus the bag. In fact its atmosphere is so thin that it resembles the attenuated gas that we call the "vacuum" of our electric light bulbs or radio tubes.

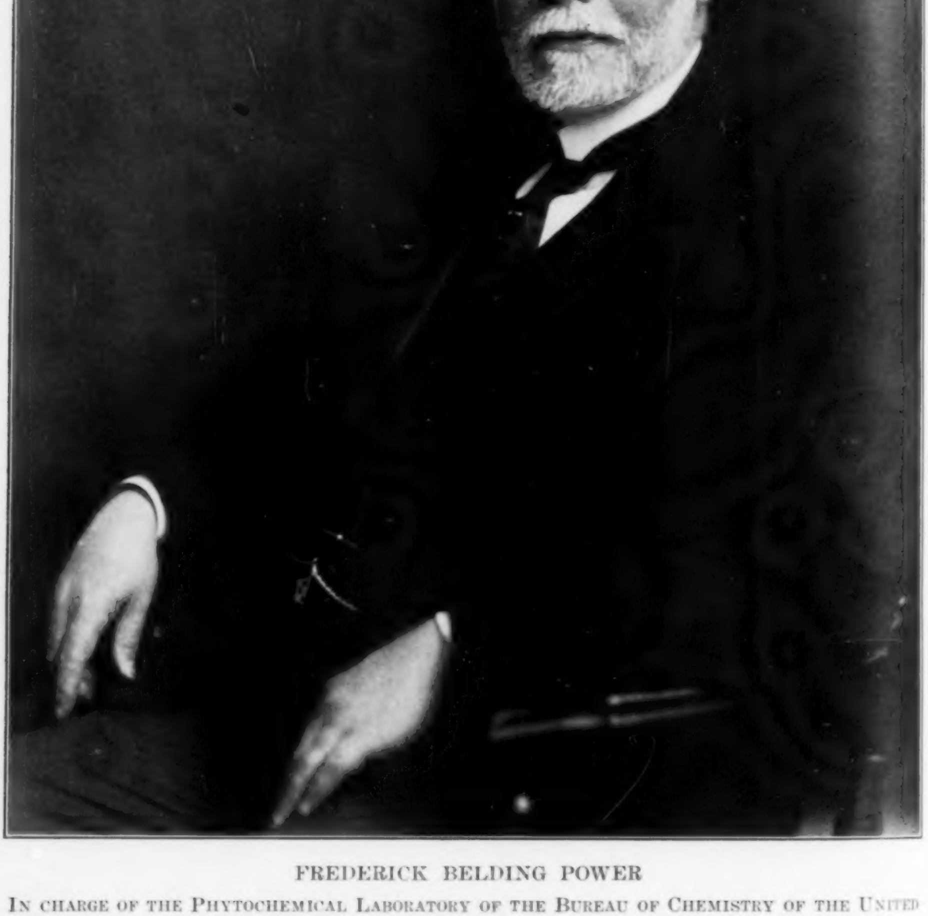
Stars differ vastly in volume but not so much in mass. The astronomer can not find any that is very many times heavier than Betelgeuse. And he wonders why. Might there not exist a star that would be fifty million times as heavy as well as fifty million times as big as the sun?

"No," says Einstein. For if there were, it would upset his law of gravitation. Professor Eddington, of Cambridge, in his new book, "The Internal Constitution of the Stars," gives three reasons why the relativity theory sets a limit to the conceivable size of visible stars. First, because light acts as though attracted by large masses of matter, and the force of gravitation of such a massive sphere would be so great that the rays of light could not get away from its surface. They would fall back to the star like a stone to the earth. Second, it has been found that the spectral lines of light from a heavy shining body, like a star, is shifted toward the red end of the spectrum, and, in the case of a giant star as dense as the sun, all the lines would be shifted so far that the spectrum would go out of existence. Third, according to Einstein, a heavy body somehow crumples up space in its vicinity, and so immense a mass of matter as we are imagining would be sufficient to close up the space around the star and leave us shut outside of the universe; that is to say, nowhere.

This reminds me of a big bedfellow I used to bunk with who would wrap the blankets close about him and leave me out in the cold. Also it reminds me of a rat I was told about when I was a boy, which could never be caught, for when he ran into a hole he pulled the hole in after him.

Professor Eddington evidently anticipates that his argument may arouse surprise or skepticism for he says that lest it be "regarded as ultra-modern by more conservative readers," he hastens to add, that Laplace, founder of modern astronomy, arrived, over a century ago, at a similar conclusion, that a star of such mass would be too big to be seen and "it is therefore possible that the largest luminous bodies in the universe may, through this cause, be invisible."

Anyhow it's nice to know that no star can grow so large, through the merger of other stellar systems, that it will monopolize the universe and crowd the rest of us out of space and time.



FREDERICK BELDING POWER

In charge of the Phytochemical Laboratory of the Bureau of Chemistry of the United States Department of Agriculture from 1816 until his death; previously, for eighteen years, director of the Wellcome Chemical Research Laboratories, London

THE UNSEEN LIFE OF THE SOIL

UNSEEN and unknown to almost every one, invisible because of their microscopically small size and always hidden in subterranean darkness, there is a whole swarming world of life under our feet. Its members are often weird in form, sometimes beneficent, sometimes harmful in their acts, but never for a moment, day or night, without their effect on the giant world of plants and animals and men that lives forgetfully above them.

This world of the soil microbiota, forgotten or ignored by all save a relative handful of scientists scattered over the earth, was outlined before the First International Congress of Soil Science, held in Washington, by Sir John Russell, director of the oldest and greatest agricultural experiment station in the world, at Rothamsted, England.

The effects wrought by soil bacteria, fungi, protozoa and other forms of life are manifold. Lowly plants called algae capture carbon dioxide from the air, build it into their bodies, and eventually, when they die, release their organic substances as humus for the enrichment of the soil. Many kinds of soil bacteria, both free-living and associated with other plants, are able to capture the otherwise inert and useless nitrogen gas from the air, which is eventually turned by the higher plants into meat-making proteids.

Bacteria break down dead plant and animal bodies, returning them to the dust from which they came; if it were not for this activity, the earth's surface would soon be cumbered with carcasses, with all the material basis of life locked up in them beyond recovery. This process is not a simple one, carried on by only one class of bacteria.

One gang of these microscopic wreckers goes to work, carries the process as far as its nature permits, and then quits. Another takes its place, forwards the work another stage, and in its turn passes it on to still other groups. At last the complex substances of the dead body are again the simple compounds that plants can use, and the upbuilding process begins once more.

Tearing down is as important a process in the cycle as setting up; for there are only just so many bricks for life to build with, and they must be used over and over. These lowly creatures of the soil, which may be our own unrecognized evolutionary ancestors, do the cosmos a service by plucking down our abandoned dwellings so that our descendants may make houses for themselves.

THE breath of bacteria, the carbon dioxide discarded by them as a by-product of their life-processes, comes to man's table as his daily bread. We live on the exhalations of billions of tiny beings which we never see. This, in brief paraphrase, is the revolutionary doctrine laid before the First International Congress of Soil Science, held in Washington, by Dr. Julius Stoklasa, of the Technical Institute and Experiment Station of Prague, recognized as one of the leading authorities in the world on the difficult science of plant nutrition.

The old theory that plants build their food out of carbon dioxide which they capture from the air by means of their leaves, Dr. Stoklasa said, is entirely inadequate. The supplies of this gas in the air, according to his measurements, are not sufficient to account for the sugars, starches and other substances formed by plants with the assistance of the sun's energy. But the soil solution contains a great deal of carbon in the form of bicarbonates, and this carbon is taken into the plant along with the other soil minerals used by the plant, and borne by the sap to the green parts where carbohydrate manufacture is going on.

The amounts of carbon taken in from

CARL H. EIGENMANN

PROFESSOR OF ZOOLOGY IN THE UNIVERSITY OF INDIANA FROM 1891 UNTIL HIS DEATH, DISTINGUISHED FOR HIS WORK IN ICHTHYOLOGY, MORE ESPECIALLY IN THE FRESHWATER FISHES OF TROPICAL AMERICA.

the soil, Professor Stoklasa asserted, compare in quantity with the amounts of other minerals assimilated. Thus, for every hundred pounds of carbon so absorbed, 154 pounds of nitrogen, 113 pounds of phosphoric acid, 106 pounds of potash, 33 pounds of calcium oxide and 26 pounds of magnesium oxide are taken in. This indicates a hitherto little suspected and wholly unmeasured part played by carbon dioxide in the soil.

Of course not nearly all of the carbon dioxide given off by soil bacteria gets into the plants. A great deal of it escapes upwards, into the air. But here the leaves are waiting for it, and it passes into the plants through the channels hitherto taught as orthodox according to the accepted doctrines of plant physiology. Furthermore, according to Professor Stoklasa, fertilizers added to the soil are by no means entirely for the direct benefit of the corn or clover or other crops. A large share of these plant condiments fall to the share of the bacteria, stimulating them to greater activity in the production of materials eventually used in the production of foods by the higher plants.

THE CONTRIBUTION OF SCIENTIFIC MEN TO AMERICAN INDEPENDENCE

THE one hundred and fifty-first anniversary of the United States as an independent nation reminds us of the part taken by scientific men in the establishment of the Republic. Of the five members of the committee that drafted the Declaration of Independence, three were scientists. The young statesman who composed it—Thomas Jefferson—also wrote what has been called America's "declaration of scientific independence." The veteran diplomat who corrected the original draft—Benjamin Franklin—was heaped with honors as one of the leading scientists of his time. The first man to vote for freedom on that first Fourth of July, in 1776, later founded a state scientific society and served as its first president. And other scientists were among the patriots of the Continental Congress who risked their lives to sign the Declaration.

These striking facts are brought out by private correspondence and published records which show that the founders of the nation were bold thinkers along other than political lines. Dr. Charles E. Munroe, of the U. S. Bureau of Mines, the leading authority on explosives in this country, has found papers showing that Benjamin Franklin was the first to suggest a practical system of firing gunpowder by electricity. To-day, throughout the world, blasting operations are almost universally fired in a similar manner. This is but another item in the long list of scientific achievements of this versatile man. Inventor of the lightning rod, rotary printing press, bifocal glasses, the Franklin stove, and many other things, Franklin was no less great in pure science. Only in recent years has it been realized how nearly correct were his views of the nature of electricity. And he was the first to show how storms and other weather phenomena move across the country. Such knowledge to-day makes possible the work of the Weather Bureau.

But as a great scientist of history, Franklin has a close rival. Thomas Jefferson was hardly less of a scientist. Many devices for saving labor on the farm were his invention. One was an improved plow, the first to turn the earth over as well as to break it up. But in 1782, he published America's declaration of scientific independence. This was the famous "Notes on Virginia." In it he completely refuted the idea of Count

PROFESSOR LIGHTNER WITMER

AND HIS ASSISTANTS MAKING AN EXAMINATION IN THE PSYCHOLOGICAL CLINIC OF THE UNIVERSITY OF PENNSYLVANIA, AT THE TIME OF THE CELEBRATION OF THE THIRTIETH ANNIVERSARY OF THE CLINIC.

de Buffon, eminent French zoologist, that American animals were smaller and represented fewer species than those of Europe. And to clinch his arguments, he sent over to the count many boxes of bones of living and extinct American animals. His chief interest was paleontology, study of the remains of extinct creatures. One of his discoveries was the one he called "Megalonyx" or "Great Claw," a prehistoric American fossil that has since been identified as a giant sloth. It is still called "Megalonyx jeffersoni."

Among the other members of the committee of five that drafted the Declaration, Roger Sherman can also be classed as a scientist. He made astronomical calculations for an almanac and made mathematics his hobby. Dr. Josiah Bartlett, first to vote for the Declaration, and first to sign it after President Hancock, later organized the New Hampshire State Medical Society and was its first president. Four other physicians signed the Declaration. At least one, Benjamin Rush, has won enduring fame in scientific annals. He was the first to study mental diseases in the United States. He inquired into the hereditary nature of drunkenness, the effect of decayed teeth on other parts of the body, and the effect of the body glands.

As our country has always, in time of stress, turned to its scientists for aid, so was the very origin of our country associated with men of scientific interests.

ALESSANDRO VOLTA

Volta died in Como a century ago, and the town on the beautiful Lake of Como is commemorating the centennial by an international exposition of electricity from May to October. The Italian Government has cooperated in the memorial through the issuance of postage stamps and the contribution of liberal funds. America will participate in the centennial through representation by a committee formed by the Italy-America Society and the International Electrical Commission, which hopes to announce at Como a fellowship giving a year's study in the United States to an Italian electrical engineer.

A sketch of the life of Volta, printed in the New York *Times*, tells us that he was born in Como in 1745. He was interested in physics and chemistry as a boy. During his professorship in the Royal School at Como, and the quarter of a century during which he held the chair of physics at Pavia, he discovered the organic nature of marsh gas and devised many experiments in atmospheric electricity, such as igniting gases by electrical sparks in enclosed vessels.

Of Volta's many discoveries the most dramatic was the "voltaic pile," an instrument which was used to decompose water into hydrogen and oxygen. Galvani's discovery of animal electricity led Volta to experiment with two different metals in contact, and by the use of his condensing electroscope he virtually proved his theory that the action of the current was due to the two metals.

Volta developed his electric pile of two dissimilar metals, such as zinc and copper, in contact, separated from a corresponding pair by paper or cloth soaked in weak brine. To this he added the "crown of cups," or first voltaic battery, in which strips of metal were placed in cups containing brine or weak acid. Scientists at first were divided over accepting his theories, but in the end Volta's ideas triumphed.

One of the first countries to give recognition to Volta's discoveries was Great Britain, where in 1791 the Royal Society awarded him the Copley Medal. Davy, head of the Royal Institution of London, took an interest in Volta's work and had

ALESSANDRO VOLTA

constructed a large pile consisting of several hundred disks. By this means he succeeded in isolating for the first time the metals sodium and potassium.

Napoleon, who in 1801 had summoned Volta to Paris to repeat for French savants his more important experiments, was indignant with the Academie des Sciences because the French had not made the discovery before Davy announced it. They replied that the English physicists succeeded because the funds had been furnished them for the construction of a huge voltaic pile. Napoleon provided funds for research and the French built a pile of their own. Napoleon went to inspect it shortly afterward, and to the astonishment of the custodians of the apparatus he seized the two terminals and placed them on his tongue before he could be prevented. He received a shock which rendered him speechless.

The English scientists made further use of Volta's discovery by raising public funds for the construction of an unusually large pile consisting of 2,000 pairs of plates. The first experiment made with this resulted in the production of electric arc light between two carbon poles in the laboratories of the Royal Institution.

Volta was made director of the philosophical faculty of Padua by the Emperor of Austria in 1815, but held the post only four years when he resigned to spend the remander of his days in Como. Napoleon honored him with the title of count and senator of the kingdom of Lombardy, and had a medal struck for him. Commemorative of the discovery of the voltaic cell, a centennial exposition was held in Como in 1899 with unfortunate results. During its progress a number of valuable Volta relics and manuscripts were destroyed by fire.

THE TOTAL ECLIPSE OF THE SUN

THE total eclipse of the sun that occurred on June 29 was not favorable for scientific observations as it was early in the morning, of short duration and in regions where the weather was not likely to be favorable. It was, however, of much popular interest, especially in England, where there has been no total eclipse since 1724 and will not be another until 1999, then only just touching the southwestern tip of Cornwall. It was mostly raining or cloudy in England, Manchester having sent the characteristic report "The sun here was eclipsed as usual."

While the phenomenon was obscured by rain, mists and clouds in most parts of the country, Giggleswick, where Sir Frank Dyson, astronomer royal, was stationed with the Royal Observatory expedition, enjoyed a perfect view during the period of totality. It was rare good fortune for, up to three minutes before the eclipse began, the sky there too was obscured by clouds which returned almost as soon as it was over and rain fell.

There were three official British astronomical expeditions, in addition to that of Sir Frank Dyson. One, under Major Lockyer, of the Sidmouth Observatory, was stationed at Richmond, Yorkshire; another, under Professor H. H. Turner and Dr. Knox Shaw, of Oxford, was at Southport, while the third, under Professor H. P. Newall, of Cambridge, went to Aal, Norway.

Cloudy weather prevailed at Fagernes, north of Oslo, and at Aal, preventing successful observations by the American astronomical expeditions gathered there. In the American party at Fagernes were Professor S. A. Mitchell, director of the Leander McCormick Observatory of the University of Virginia, and Professor

—*From Punch*

Vicar.—"I FIND OUR ANNUAL GARDEN FETE IS FIXED FOR THE SAME DAY AS THE ECLIPSE. I THINK I MUST GET IT PUT OFF."

Gardener.—"YOU COULDN'T 'ARDLY DO THAT, SIR—NOT A *total* ECLIPSE YOU COULDN'T."

Harlan T. Stetson, of Harvard University.

At Ringebu, in Gudbrandsdal, however, and at Nyborgmön, in Finmark, weather conditions were perfect and excellent observations were made and photographs taken by the Norwegian Professors Säland and Vegard at the former, and by the German Professor Linke and M. Krogness, director of the Geophysical Institute of Tromsö at the latter.